Accessions
(26,566)

Shelf No.
~~*7951.48~~
Adams 754
.R54E

FOUNDED 1852
BOSTON PUBLIC LIBRARY

GIVEN BY
Hon. Chas. F. Adams
July 2, 1891.

Heliotype Printing Co. Boston

THE ELEMENTS OF NAVIGATION;

CONTAINING THE

THEORY and PRACTICE.

With all the neceſſary TABLES.

To which is added,

A TREATISE of

Marine Fortification.

For the USE of the ROYAL MATHEMATICAL SCHOOL at
CHRIST'S HOSPITAL, and the GENTLEMEN of the NAVY.

In TWO VOLUMES.

By J. ROBERTSON, F.R.S.
Mathematical Maſter at CHRIST'S HOSPITAL.

LONDON,
Printed for J. NOURSE, at the *Lamb*, oppoſite *Katherine-Street*, in the *Strand*. MDCCLIV.

1754

Adams
754
R54E

noticed in Bo. C. 1780. 24
1 vol only

(26.566)

Hon. Chas. F. Adams,
July 2, 1891.

TO THE

RIGHT WORSHIPFUL

Sir JOHN BARNARD, Knt. Alderman,

PRESIDENT;

THE

Worſhipful PHILIP SCARTH, Eſq;

TREASURER;

And the reſt of the

WORSHIPFUL GOVERNORS

OF

Chriſt's Hoſpital, London:

This Book, containing the Elements of Navigation, and a Treatiſe on Marine Fortification, compoſed for the Uſe of the Children in the Royal Mathematical School, committed to my care by your WORSHIPS Favour, is, as a grateful Acknowledgment, humbly dedicated, by

Your WORSHIPS moſt humble, and

moſt obedient Servant,

John Robertſon.

THE

PREFACE.

IT having been part of my employment for many years paſt to inſtruct youth both in the Theoretical and Practical parts of the art of Navigation, I was naturally led to draw up rules and examples fitted to the years and capacity of the ſcholar: Some of the precepts have from time to time been altered, according as I had obſerved how they were comprehended by the majority of my pupils; until at length I had put together a ſet of materials which I found ſufficient for teaching this Art.

Upon my being intruſted by the Governors of Chriſt's Hoſpital with the care of the Royal Mathematical School there, founded by King Charles the Second, I had a great opportunity of experiencing the method I had before uſed; and finding it fully anſwered my expectation, I determined to print it for the uſe of that ſchool: But as thoſe children are to be inſtructed in the mathematical ſciences, on which the art of Navigation is founded, I judged it proper, on their account, to introduce the ſubjects of Arithmetic, Geometry, Trigonometry, &c.; and for this reaſon, the title of the Elements of Navigation *was choſen whereby to diſtinguiſh this treatiſe.*

The enſuing work I have divided into ten Parts or Books, each being a diſtinct treatiſe, containing every neceſſary element which would be wanted in the ſucceeding articles. The demonſtrations of the ſeveral propoſitions are given in as conciſe a manner as I could contrive, to carry with them a ſufficient degree of evidence. Throughout the whole of the elementary parts, I have aimed at brevity and perſpicuity; but in the practical parts, have been more full, and, as I apprehend, have included every uſeful particular worthy the mariner's notice: However, as I am ſenſible that the moſt knowing and careful perſon may overlook ſlips in his own compoſitions, which may be diſcovered by others; therefore, at my requeſt, the greateſt part of the manuſcript was read and examined by two of my friends, Mr. William Mountaine, F. R. S., and Mr. William Payne, gentlemen well acquainted with the ſubject of Navigation; who, by their judicious obſervations, enabled me to improve ſome articles, for which I eſteem myſelf much obliged to them.

The Reader will find in almoſt every book a conſiderable deviation, in point of method, from moſt authors: In the elementary parts, where it is no eaſy matter to introduce new Subjects, there will be found, however, the old ones treated of in a manner which, it is apprehended, is better adapted to beginners, and even ſuch new lights thrown on ſeveral particulars, as will *render them more eaſy, than in the view wherein they have been hitherto ſeen.*

The Maritime parts of this work, contained in the VIth, VIIth, and IXth books, are delivered in a manner ſomewhat different from that of other writers on this ſubject: Who, for the moſt part, copying from one another, may be perhaps one reaſon why the art of Navigation has been ſo little improved within the laſt 150 *years; for excepting what* Norwood *and* Halley *have done, the art ſeems much in the ſame ſtate in which* Wright *left it: However, I apprehend that the proper judges will, from the method I have taken, find ſome few improvements, if not in the art itſelf, at leaſt in the manner of communicating it to learners.*

The treatiſe of Fortification annexed to this work, is the reſult of many years application; and as I thought ſuch a piece might be advantageous to the Gentlemen of the Navy, as well as to the children of the Mathematical School, I judged it would not be unacceptable. In this treatiſe I have alſo taken a track very different from what other writers have purſued; for among the multitude which I have ſeen, they all begin, as near as I can recollect, with the fortifying of a town, the moſt difficult part of the art, and end with works that are the moſt eaſy to contrive and execute: However, I have ventured at beginning with the works of the ſimpleſt conſtruction, and proceeded thence, through the different gradations, to the fortifying a town: And although the ſmall limits, to which I have confined myſelf, have indeed obliged me to be very ſhort in ſome articles, and totally to omit many others; nevertheleſs I conceive, that in its preſent ſtate it may be of conſiderable uſe to mariners, and even furniſh ſome hints not altogether unworthy the notice of the Gentlemen of the Army; to whom I may, perhaps, ſome time hence, preſent a much larger work on this ſubject, ſhould this meet with their approbation.

I have always thought, that the chief motives which ought to induce a perſon to appear as an author, ſhould be, either the having ſomething new to publiſh, or ſome new lights to throw on thoſe already publiſhed; in either of theſe caſes he cannot be a proper judge, unleſs he has ſeen the pieces already extant on that ſubject; or at leaſt, thoſe of the moſt eminent authors in the ſeveral preceding ages: On this account I was led to examine what had been done by the different writers on the ſubject of Navigation; and having peruſed almoſt every book, wherein that art had been handled, of which I could get information (and I believe few have eſcaped my enquiry), I drew up for my own amuſement an account of thoſe ſeveral works; whereby I had an opportunity of diſcovering the ſteps by which this art has riſen to its preſent perfection, and conſequently, of knowing the moſt material parts of the hiſtory of its progreſs; and this enabled me, among other things, to rectify one miſtake which has crept into moſt of the modern books of Navigation; which is, that Wright's invention of making a true ſea-chart was ſtolen by Mercator, and publiſhed as his own. I ſuſpect this ſtory had its riſe from a book printed in the year 1675 *by Edward Sherburne, intitled the ſphere of Marcus Manilius made an Engliſh poem, with annotations and an aſtronomical appendix.*

PREFACE.

In the catalogue of aſtronomers, in page 86, *the author ſays:* "*Mr.* EDWABD WRIGHT, *contemporary with Mr.* Briggs *before mentioned, having ſpent ſome time in* Cambridge, *and being naturally addicted to* Mathematical Studies, *was perſuaded to accompany, and went along with the* Right Honourable George Earl of Cumberland, *in his expedition to the* Azores, *in the year* 1589, *on purpoſe to add the practice of Navigation to the theory; and in the year* 1599, *he publiſhed his book called the* Errors in Navigation. *A moſt excellent work for the true deſcribing a ſea-chart; which invention of his, Gerardus Mercator publiſhed, without owning the author.*"

Now the fact is, that Gerard Mercator, about the year 1550, *publiſhed a Map of the world, wherein the degrees of latitude were increaſed from the equator towards the poles; and hence it was, that charts with the degrees of latitude increaſing, were called Mercator's charts. Mr. Wright, it is likely, was born about the year* 1560, *he being admitted of Caius College, Cambridge, about the year* 1582, *and about the year* 1590, *communicated to ſome acquaintance the principles upon which the degrees of latitude ſhould be increaſed; and, among others, to Jodocus Hondius, a map-graver, who going to Holland, publiſhed the method without the author's conſent; and of this Wright complains in the preface to his Errors in Navigation. But before this was publiſhed, Mercator died, in the year* 1594, *and it does not appear that he had done any thing in the latter years of his life; therefore it is not probable that any of Wright's inventions could have been publiſhed by Gerard Mercator. Mr. Wright died about the year* 1616, *and Nicholas Mercator, he who ſquared the hyperbola about* 52 *years afterwards, and the perſon charged by ſome of the writers on Navigation with the foreſaid theft, does not appear to have had any other concerns with Navigation, than the offering to lay a wager about the demonſtration of the logarithmic tangents being analogous to the meridional parts: So that the ſtory, intended to aſſert Wright's invention (which was undoubtedly his own, Mercator's degrees not being increaſed in their true proportion), contains ſuch a variety of abſurdities, as could never have ariſen but by truſting to hearſay opinions, originally ſpread from miſconceiving Wright's own account.*

I have taken ſome pains to ſettle this affair, and hope it will afford entertainment to the curious in theſe matters, as well as give a caution to thoſe who may hereafter chuſe to mention the inventors of the Mercator's chart.

Chriſt's Hoſpital,
December 24, 1753.

J. R.

ADVERTISEMENT.

AS it may be expected that four kinds of readers will look into this book, it was thought convenient to point out to ſome of them, the places where they may meet with what they more particularly want.

First. Thoſe who having made a proficiency in the mathematics, will, it is likely, examine in what manner the ſubjects are here treated, and whether any thing new is contained therein: It is conceived that ſuch readers will find ſome things which may recompence them for their trouble, in almoſt every one of the books.

Secondly. Thoſe learners who are deſirous of being inſtructed in the art of Navigation in a ſcientific manner, and would chuſe to ſee the reaſon of the ſeveral ſteps they muſt take to acquire it: To ſuch perſons, it is recommended that they read the whole book in the order they find it: Or, if the learner is very young, he may omit the fourth book till after he is maſter of the fifth and ſixth. Adult perſons, and thoſe under the direction of a maſter, may, if they pleaſe, read the VIIIth book immediately after the Vth; and read the VIth, VIIth and IXth books in ſucceſſion.

Thirdly. That claſs of readers, which, with too much truth may be ſaid, comprehends moſt of our mariners, who want to learn both the Elements and the Art itſelf by rote, and never trouble themſelves about the reaſon of the rules they work by: As there ever will be many readers of this kind, they may be well accommodated in this work; thus, if they are not already acquainted with Arithmetic and Geometry, let them read the five firſt rules of Arithmetic, to page 20th; thence proceed to the definitions and problems in Geometry, from page 42 to 55. In the book of Trigonometry, read pages 83, 84, 85, 86, 92, 93, and from 98th to 108th: The whole of book V. In book the VIth he may read to page 267, and as much more as he pleaſes. In book VII, let him read the ſections III, IV, V, VI, from page 368 to page 407. In book VIII he may read ſection III, and as many problems in the Vth and VIth ſections as he can; and let him read the whole of the ninth book.

Fourthly. That ſet of Readers who will not be at the pains of learning any thing more than how to do the practice of a Day's work: Such may herein meet with the practice almoſt independent of other knowledge. Let ſuch perſons make themſelves acquainted with ſection VIII of book V, and the uſe of the table at page 200; then learn the uſe of the Traverſe table at the end of book VI, which he will find exemplified between pages 243 and 274; alſo he muſt learn the uſe of the Table of meridional parts at page 423: After which, he may proceed to book IX, where he will find ample inſtructions in all the particulars which enter into a Day's work. But as with this ſcanty knowledge of things he will not clearly ſee every part of book IX, he may omit the articles 1059, 1091, 1106, and the XIth and XIIth ſections.

THE

CONTENTS.

The ſections refer to the page; the particulars to the N° of the article.

BOOK I. ARITHMETIC.

Section I. Definitions and Principles, p. 1.

Notation, numeration and fractions arts. 13, 14, 15, 16,

Signs and decimal tables arts. 22, 23

Section II. Addition p. 6.

Of whole numbers and fractions 24

Section III. Subtraction, p. 8.

Of whole numbers and fractions 26

Queſtions to exerciſe addition and ſubtraction 27

Section IV. Multiplication, p. 10.

Multiplication table 29

Multiplication of whole numbers and fractions 30

Section V. Diviſion, p. 12.

Of whole numbers and fractions 32

Section VI. Reduction, p. 14.

To reduce numbers of ſeveral names to one name 35

To reduce a number in one name to ſeveral names 36

To reduce vulgar fractions to decimal ones 38

To reduce different names to a decimal fraction 40

To value a decimal fraction 42

Practical queſtions 43

Section VII. Of Proportion, p. 20.

Of the nature of proportional numbers 44

The Rule of Three 46

A collection of 26 *queſtions* 47

Section VIII. Of Powers and Roots, p. 26.

To raiſe numbers to a propoſed power 50

To extract the ſquare root 54

To extract the cube root 56

Section IX. Of Numeral ſeries, p. 30.

Of arithmetic progreſſion 59

Of geometric progreſſion 60

Four problems in progreſſions 64 *to* 73

Section X. Of Logarithms, p. 34.

Of the nature of logarithms 73

To make logarithms 77

Of the tables of logarithms 80

Of the indices of logarithms 82

Multiplication and diviſion by logarithms 85

Proportions by logarithms 87

Of powers and roots by logarithms 90

BOOK II. GEOMETRY.

Section I. Definitions and Principles, p. 42.

Definitions art. 92

Poſtulates 134

Axioms art. 137

Section II. Problems, p. 47.
Of right lines and figures 146, 166
Of proportional lines 166
Scales of equal parts and chords 172, 174
Section III. Theorems, p. 57.
Of right lines and triangles 181, 196
Of quadrangles and the circle 196, 220
Section IV. Of Proportion, p. 65.
Definitions and principles 221
General properties 231
In ſimilar triangles 248
In the circle and regular polygons 252
Quadrature of the circle 266
Section V. Planes and Solids, p. 77.
Definitions and principles 272
Properties of cutting planes 283
Section of pyramids and cones 285
Section VI. Of the Spiral, p. 80.
Of the common ſpiral 287
Proportional ſpiral 288
Logarithmic ſpiral 292
Of Napier's logarithms 295

BOOK III. PLANE TRIGONOMETRY.

Section I. Definitions and Principles, p. 83.
Definitions art. 296
Axioms art. 305
Section II. Of the Triangular canon, p. 86.
Conſtruction of the plane ſcale 312
Of the ſines of ſmall arcs 320
Of ſines above 60 degrees 324
To compute the tangs. and ſecants 326
To compute the ſines 333
Of the tables of ſines and tangents 334
Section III. Of the ſolution of Plane triangles, p. 94.
By oppoſite ſides and angles 340
By two ſides and the included right angle 341
By two ſides and the included oblique angle 343
By the three ſides 344
Synopſis of the rules 347
Twelve numeral examples 348
Section IV. Deſcription and uſe of Gunter's ſcale, p. 108.
Of natural and logarithmic ſcales 361, 362
Of the line of numbers 363
Of the lines of ſines and tangents 364, 365
Of the line of verſed ſines 366
Demonſtrat. of their conſtruction 367
The uſe in plane trigonometry 371

BOOK IV. OF SPHERICS.

Section I. Definitions and Principles, p. 116.
Definitions art. 381
Axioms art. 396
Section II. Stereographic Propoſitions, p. 119.
Twenty nine properties in ſtereographic projections 410 *to* 440
Section III. Spherical Geometry, p. 126.
Thirty ſeven caſes of projections exemplified and demonſtrated 440 *to* 462
Section IV. Spherical Trigonometry, p. 136.
Definitions and principles 462
Section V. Spherical Theorems, p. 137.
Fifteen propoſitions 470 *to* 494
Section VI. Solution of Right angled ſpheric triangles, p. 143.
By two new rules 494
By Napier's general rule 502

Section VII. Solution of Oblique angled ſpheric triangles, p. 148.
Of the neceſſary preparations 503
Four problems ſolved by drawing a perpendicular 504
The ſolution when three ſides or angles are given, with their demonſtrations 508
Synopſis of all the caſes of right angled ſpherics 510
Synopſis of all the caſes of oblique angled ſpherics 527
Section VIII. The conſtruction and numeral ſolution of the caſes of right angled ſpheric triangles, p. 156.
Six examples and ten conſtructions from 539 to 545
Example of a quadrantal triangle 545
Section IX. The conſtruction and numeral ſolution of the caſes of oblique angled ſpheric triangles, p. 163.
Six examples 546 to 551
A plate at page 152.

BOOK V. GEOGRAPHY.

Section I. Definitions and Principles, p. 169.
Definitions art. 552
Diviſion of the earth into zones 564
Diviſion of the earth by climates art. 568
Section II. The natural diviſion of the earth, p. 172.
Definitions 569
Of continents 583
Of oceans 584
Section III. The political diviſion of the earth, p. 174.
Of Europe and its chief parts 585
Of Aſia and its chief parts 589
Of Africa and its chief parts 593
Of America and its chief parts 597
Section IV. Of Winds, p. 182.
Air and Atmoſphere 602
Trade winds and monſoons 608
Dr. Halley's obſervations 608
Section V. Of Tides, p. 187.
Of gravitation and attraction 610, 611
Cauſe of the general tides 614
Chief propoſitions on tides 615
Obſervat. on tides about England 624
Section VI. Chronology, p. 192.
Of æra's or epocha's 629
Julian account, or old ſtile 632
Gregorian account, or new ſtile 633
Of the calendar 634
Nine chronological problems 645
Section VII. Geographical Problems, p. 200.
Four problems concerning the difference of latitude, and diff. longit. 654 to 659
A Table of the latitudes and longitudes of the moſt conſiderable places on the ſea coaſts of the known parts of the world, together with a tide table, p. 204.

BOOK VI. PLANE SAILING.

Section I. Definitions and Principles, p. 233.
Definitions art. 660
Neceſſary elements 661
The nature of maps art. 662
Section II. Conſtruction and uſe of the plane chart, p. 235.
The conſtruction of the plane chart 664
Its uſe exemplified in ſeven caſes 665
Section III. Plane ſailing, p. 238.
Definitions and principles 672
General directions for conſtruction 681
Of the Traverſe table 683

Proportions, making either ſide radius 684
Table of the moſt uſeful proportions or canons in plane ſailing 685
Table of the angles which the points of the compaſs make with the meridian 686

Section IV. Of Single courſes, p. 243.

The ſix caſes of plane ſailing 687 to 693
Eight queſtions to exerciſe the caſes 693

Section V. Compound courſes, p. 253.

To work a traverſe 695
To conſtruct a traverſe 696
To conſtruct a compound courſe 698
Twenty queſtions in compd. courſes 699

Section VI. Oblique ſailing, p. 267.

Of the bearing and ſetting of objects 700
Twenty queſtions and their ſolutions.

Section VII. Sailing to windward, p. 274.

Definitions 701
General conſtruction 705
Twenty queſtions and their ſolutions.

Section VIII. Current ſailing, p. 283.

Definitions and principles 706
General conſtruction 708
Twenty queſtions and their ſolutions.

Section IX. Miſcellaneous queſtions, p. 292.

Twenty complicated queſtions with their ſolutions.
A Traverſe table to every point and quarter point of the compaſs art. 711
A Traverſe table to every degree and quarter degree of the compaſs art. 712
Five plates, at pages 252, 274, 282, 292, 302.

BOOK VII. GLOBULAR SAILING.

Section I. Definitions and Principles, p. 353.

Of a ſhip's true place at ſea art. 714
Of Mercator's chart 716
Of Wright's conſtruction art. 718

Section II. Of the reckoning of longitude in 14 propoſitions, p. 356.

Of the meridional parts by the ſecants 724
To conſtruct a true ſea chart 725
Truth of ſailing by Mercator's chart 727
Of the ſpiral rhumbs on the globe 733
The meridional parts by the logarithmic tangents 736

Section III. Parallel ſailing, p. 368.

Principles and rules 743
Table ſhewing the meridional diſtance between two meridians in every latitude 747
Uſes of the table 748
The ſeveral caſes of parallel ſailing 750

Section IV. Middle latitude and Mercator's ſailing, p. 374.

Principles and rules for middle latitude 756
Principles and rules for Mercator's ſailing 761
Eleven problems including the uſual varieties in Mercator's ſailing, ſolved by middle lat. Mercator and log. tang. 765 *to* 785

Section V. Compound courſes corrected by longitude, p. 394.

Principles and rules 785
Examples ſolved both by middle latitude and Mercator's ſailings 788

Section VI. The uſe of a Mercator chart, p. 399.

Of the lines of longitude and latitude on the Gunter's ſcale 792
Thirteen problems concerning the conſtruction and uſe of the chart 791 *to* 809

Section

Section VII. Great circle ſailing, p. 407.
The ſix caſes in a ſingle courſe 811
Concerning compound courſes 818
Three queſtions in compd. courſes 819
Of the figure of the earth 824
To reduce ſpheric meridional parts to the ſpheroid 825
To find the difference of latitude on the ſpheroid 826
A Table of meridional parts to every degree and minute of the quadrant 827
Two plates placed at page 422.

BOOK VIII. ASTRONOMY.

Section I. Solar Aſtronomy, p. 433.
Of the ſolar ſyſtem art. 829
Number of conſtellations and ſtars 834
Primary and ſecondary planets 839
Annual and diurnal motions 844
Elliptic orbits of the planets 849
Kepler's laws 856
Conjunctions and oppoſitions art. 861
Table of the ſolar ſyſtem 864
Of the ſecondary planets motion 865
Of the figure and light of the planets 867
Section II. Terreſtrial Aſtronomy, p. 442.
Of the direct, ſtationary, and retrograde motions 872
Phenomena of the inferior planets 873
Phenomena of the ſuperior planets 876
Apparent motion of the ſun 877
Obliquity of the ecliptic 882
Of the different ſeaſons 883
Of the riſing and ſetting of the ſtars 892
Of parallaxes 893
Of the meaſure of the earth 900
Of the moon 901
Of ſolar and lunar eclipſes 906
Section III. The Aſtronomy of the ſphere, p. 451.
Definitions and principles 916
To convert time into degrees, and the contrary 958
Of the tables of declination and right aſcenſion 961
To correct the ſun's declination for any meridian 964
To find the ſun's declination at any time and place 965
To find the culminating of the ſtars 966
Section IV. Of the Projection of the ſphere, p. 458.
The projection of the circles of the ſphere on the four chief great circles 968
Section V. Aſtronomical problems, p. 461.
Fifteen problems of the ſphere, with their conſtruction and numeral ſolution 972 *to* 1006
Section VI. Various methods to find the latitude, p. 475.
Fourteen aſtronomical problems for finding the latitude of a place from various obſervations 1006 *to* 1022
Section VII. Miſcellaneous problems, p. 484.
Seven aſtronomical problems on various obſervations 1022
Section VIII. Uſe of the Globes, p. 488.
Twenty two problems on the celeſtial and terreſtrial globes 1029 *to* 1052
A Table of the ſun's declination, page 496, 1052
A Table of the ſun's right aſcenſion, page 500, 1053
A Table of the right aſcenſions and declinations of ſome of the fixed ſtars, page 501, 1054
A Table to correct the ſun's declination to any meridian 1055
A Table of refractions 1056
Two plates, at pages 462, 484.

BOOK IX. OF DAYS WORKS.

Section I. Of meaſuring a ſhip's run, p. 504.
Of the log, log-line, and half-minute glaſs art. 1058
How the log and line meaſures a ſhip's way art. 1059
Of the correction on the log-line and glaſs 1060

Section II. Of the mariner's compaſs, p. 506.
The conſtruction and properties 1063
The imperfections and amendments 1064
The diſcovery of the variation 1065
The azimuth compaſs and how to obſerve by it 1066,1067

Section III. To work an amplitude, p. 509.
Solution by logarithms 1071
Solution by the Traverſe table 1072

Section IV. To work an azimuth, p. 511.
Solution by the logarithms 1074
Solution by the Gunter's ſcale 1075

Section V. Variation of the compaſs, p. 514.
What the variation is, and how reckoned 1076
To find the variation 1077
To correct courſes by the variat. 1078

Section VI. Of Leeway, p. 516.
What lee-way is 1079
Allowances for lee-way 1080
To correct courſes by lee-way 1081

Section VII. Of Inſtruments for taking altitudes, p. 517.
Deſcription of Davis's quadrant 1082
To obſerve the ſun's altitude by Davis's quadrant 1083
Deſcription of Hadley's quadrant 1087
To take altitudes by Hadley's quadrant 1088
Corrections for the horizontal dips and refractions 1091
Table of corrections, and how uſed 1093
To make an artificial horizon 1098

Section VIII. To find the latitude by obſervation, p. 526.
Preparation and rules 1102
Fourteen examples in various caſes.

Section IX. Of a Ship's reckoning, p. 529.
Of dead reckoning and log-book 1106
Various methods of correcting the account of longitude 1109
1ſt Method, the courſe being leſs than three points 1112
2d Method, courſe more than five points 1113
3d Method, courſe being about four points 1114
4th Method, by the variation chart 1116
5th Method, from celeſtial obſervations 1119

Section X. Of a Sea journal, p. 536.
General precepts 1127
Six independent days works 1128
General obſervations 1135
Journal of a voyage from England towards Madeira, ſuppoſed to be performed in 21 days, with each day's work 1136

Section XI. Surveying of coaſts and harbours, p. 555.
To take a ſurvey on ſhipboard 1137
To take a ſurvey on ſhore 1138

Section XII. To eſtimate diſtances, p. 558.
Of the motion of ſound 1139
How to find diſtances by the flight of ſound 1140
Of the curvature of the earth 1141
To find at what diſtance at ſea an object on the water may be ſeen from a known elevation 1142
A Table for finding the diſtance of objects at ſea 1145
Remarks on the uſe of ſome tables 1146

Table

Table of the Logarithms of numbers from 1 *to* 120 1149
Table of Logarithmic Sines, Tangents and Secants, to every point and quarter point of the compaſs 1150
Table of the Logarithms of numbers from 100 *to* 10000 1151
Table of the Logarithmic Sines and Tangents to every degree and minute of the quadrant 1152
A plate at page 528.

FORTIFICATION.

PART I. *Of Land Fortifications.*

Section I. Of Lines or Intrenchments, p. 604.
What fortification is art. 2
What lines are, and where placed 6
To caſt up a line acroſs a paſs 9
Table of the dimenſions of lines art. 11
Of the profile of lines 13
Of the plans of lines with redents 17

Section II. Of Batteries, p. 609.
Of the nature and kinds of batteries 19
Of the ditch and parapet 22, 23
Of the platform and magazine 28, 32
To conſtruct a faſcine battery 34
To conſtruct a coffer battery 38
To make a gabion battery 40
Table for the conſtruction of batteries 42
To conſtruct the plans of embraſures 46
Of the profiles of batteries 50

Section III. Of Additional works, p. 618.
Of ramps and barbets 51, 56
Of cavaliers and traverſes 58, 59
Of paliſades and barriers 61, 62
Of redouts and redans 63, 71

Section IV. Of the Fortifying of towns, p. 625.
Definitions and exemplifications 73, 81
General principles or maxims 85
A Table for regular fortifications 86
To fortify any polygon in the table 89
To draw the plan of the rampart 93
To draw the plan of the foſs and eſplanade 98
Of gates, private and public 104
To conſtruct the plan of a gate 108
The diſpoſition of ſtreets and buildings 109
To deſign the plan of the ſtreets and buildings 110
Of bridges, fixed and moveable 112
Of the orillon and retired flank 114
Of double and caſemated flanks 116

Section V. Of Works for the defence of the foſs, p. 640.
Of tenails and their conſtruction 118
Of caponiers 119
Of ramſhorns 120

Section VI. Of outworks, p. 641.
Neceſſary obſervations 122
Of the ravelin 123
Of Coehorn's ravelin 129
Of countergards 131
Of the tenaillon 132
Of horn and crown works 135
Of the cover'd way, glacis, and place of arms 139
Of traverſes and ſally-ways 142
Of communications 144
Of works beyond the glacis 145
Of profiles 148
Conſtruction of profiles 152
Of irregular fortification 160

PART II. *Of Marine Fortifications.*

Section I. Of the kinds and properties of harbours, p. 654.

Of artificial harbours art. 170
Of natural harbours art. 171

Section II. Of the fortifying of roads and harbours, p. 655.

Firſt ſort 174
Second ſort 177
Third ſort 183
Fourth ſort 184
Fifth ſort 185
Of the figure and ſize of forts 186
Of proper forts, and their diſpoſitions 187

Section III. Of the fortifying harbours by booms, p. 660.

To lay a boom 191
To lay a boom in a ſtreight channel 193
To ſet up a boom in the bend of a river 195
Maxims to be obſerved in fortifying a harbour and mooring the ſhipping therein 198

Section IV. Of the mooring of ſhips in fortified harbours, p. 665.

Conſiderations in mooring with regard to the ſtream 200
Conſiderations in mooring with regard to the wind 204

Section V. Of ſome remarkable actions concerning attacks of ſhips in fortified harbours, p. 667.

The battle of Santa Cruz in the year 1657 207
The action at Londonderry in the year 1689 208
The action at Gibralter in the year 1693 209
Diſpoſition of the Engliſh fleet at Cadiz 1695 210
Fortifications in the harbour of St. John in Newfoundland 1697 211
The battle of Vigo in the year 1702 212

Two plates, at pages 624, 672.

ERRATA.

Page	line	read	Page	line	read	Page	line	read
40	27	$\overline{1}$,77815	159	2	AB	298	30	KE
43	44	EFG	192	20. 25	2228. 328	359	7	5795 for 6795
52	6	ſemicircle	205	35	Anholt 12° 00′ E.		32	8 ſubdiviſions
53	7. 9	C *a*. C *b*	207	49	C Bon. Eſp. 34° 15′ S.	373	28	*e d* for E *d*
53	laſt but 3	draw *r s* parallel to C *a*	208	20	Bridge-T.	397	1	67° 30′
63	9	180°*		22	59° 50′ W. Brill 4° 10′ Eaſt	421	14	2217. 2211
70	16	dele ad	209	48	C. Caſſander 23° 41′ E.	440	15 of art. 865	the plane
70	laſt but 4	(249)	246	29	33° 13′	463	1. 5	VI. 20° 43′
89	4	S. 25° + S. 35°	258	laſt but 2	209,9	466	30	51° 32′
100	28. 29	dele the =s	259	4	difference (for preſent)	468	32	113° 00′
	30. 31	next the logarithms	260	26	S. 14° 55′ Weſt		37. 38	co-alt.
106	25	½ $\overline{G+D}$	279	18	lighthouſes	469	22	=∠ZP⊙
108	13	and on the other ſide	293	37	ſolution	472	28	10,50860
132	3	that	296	8. 32	SW. b. W. SE.	475	39	RP
142	2. 3	CK, ADFB				477	29	22° 30′
150	11. 24	(2d. 497)				503	laſt	currant
153	5	coſ. adj. ∠				512	14	40° 38′
154	4	cot: m					20. 22	9,95185
							23	9,96992

THE

THE ELEMENTS OF NAVIGATION.

BOOK I.
OF ARITHMETICK.

SECTION I.
Definitions and *Principles.*

1. ARITHMETIC is a ſcience which teaches the properties of numbers; and how to compute, or eſtimate the value of things.

2. An UNIT or UNITY, is any thing conſidered as one.

3. NUMBER is many units.

4. DIGITS or FIGURES are the marks by which numbers are denoted or expreſſed, and are the nine following.

Digits,	1.	2.	3.	4.	5.	6.	7.	8.	9.
Names,	One.	Two.	Three.	Four.	Five.	Six.	Seven.	Eight.	Nine.

And with theſe there is uſed the mark 0, called cypher, which of itſelf ſtands for nothing; but being annexed to a digit alters its value. Thus 40 ſignifies forty: and 400 ſtands for four hundred, &c.

5. INTEGER, or WHOLE, NUMBERS, are ſuch as expreſs a number of things, whereof each is conſidered as an unit.

Thus four pounds, twelve miles, thirty four gallons, one hundred days &c. is in each caſe called an integer number, or whole number.

6. FRACTIONAL NUMBERS, are ſuch which expreſs the value of ſome part or parts of an integer unit.

Thus one half, one quarter, three quarters, &c. are each the fractional parts of an unit.

7. NOTATION is the expreſſing by digits or figures any number propoſed in words; and the reading of any number that is expreſſed by figures, is called NUMERATION.

8. DECIMAL NOTATION is that kind of numbering wherein ten units of any inferior name are equal in value to an unit of the next ſuperior.

9. Every number is ſaid to conſiſt of as many places as it contains figures.

10. The value of every digit in any number is changed according to the place it ſtands in: and the reading of any number, conſiſts in giving to each figure therein its right name and value.

11. The right hand place of an integer number is called the place of units; and from this place all numbers begin, whether *whole* or *fractional*; the integers increaſing in the order from the unit place towards the left; and the fractions decreaſing in the order from the unit place towards the right: And to diſtinguiſh decimal fractions from integers, there is always a point or comma (,) ſet on the left hand ſide of the fractional number; ſo that the integers ſtand on the left hand ſide of the mark, and the fractions on the right hand.

12. For the more convenient reading of numbers, they are divided into periods of ſix places each, beginning at the unit place: and each period into two degrees of three places each, whoſe names and order are as follows: Where X ſtands for the word tens, C for hundreds, and Th. for thouſands.

13.

		Integers												Decimal fractions												
		Second period						Firſt period						Firſt period						Second period						
		Degree			Degree			Degree			Degree			Degree			Degree			Degree			Degree			
&c.	Billions	C. Th. Millions	X. Th. Millions	Th. Millions	C. Millions	X. Millions	Millions	C. Thouſands	X. Thouſands	Thouſands	Hundreds	Tens	Units	Tenths	Hundredths	Thouſandths	X. Thouſandths	C. Thouſandths	Millionths	X. Millionths	C. Millionths	Th. Millions	X. Th. Millions	C. Th. Millions	Billionths	&c.
	5	4	3	2	1	2	3	4	5	6	7	8	9,	8	7	6	5	4	3	2	1	2	3	4	5	
Decimal Fractions are alſo thus named,														Primes	Seconds	Thirds	Fourths	Fifths	Sixths	Sevenths	Eighths	Ninths	Tenths	Elevenths	Twelfths	&c.

The name of the firſt period, is units; of the ſecond, millions; of the third, Billions; of the fourth, Trillions; &c.

In the above order it may be obſerved, that each degree contains the names of Units, Tens, Hundreds; the firſt degree of a period contains the units of that period, and the ſecond contains the thouſands thereof: So that from hence it will be eaſy to read a number conſiſting of ever ſo many places by the following directions.

14. Rule, 1ſt. Suppoſe the number parted into as many ſets or degrees of three places each, beginning at the unit's place, as it will admit of; and if one or two places remain, they will be the units and tens of the next degree.

2d. Beginning at the left hand, read in each degree, as many hundreds, tens and units, as the figures in thoſe places of the degree expreſs, adding the name thouſands, if in the ſecond degree of a period; and adding the name of the period, after reading the hundreds, tens and units in its firſt degree.

Thus the integer number in the preceding table will be read. *Five billions, four hundred thirty two thouſand, one hundred twenty three millions, four hundred fifty ſix thouſand, ſeven hundred eighty nine.*

15. All fractional numbers conſiſt of two parts, which are uſually wrote one above the other with a line drawn between them: The number below the line, called the *denominator*, ſhews into how many equal parts the unit is divided: The number above the line called the *numerator*, ſhews by how many of theſe equal parts the value of that fraction is expreſſed.

Thus 9 pence, is 9 parts in twelve of a ſhilling; and may be wrote thus $\frac{9}{12}$, when a ſhilling is the unit.

16. Such fractions whoſe denominators are 10, or 100, or 1000, or 10000, or 100000, &c. are called *decimal fractions:* But fractions with any other denominators, are called *vulgar fractions.*

The vulgar fractions that moſt frequently occur, are theſe.

$\frac{1}{4}$ which is read one fourth or one quarter.
$\frac{1}{3}$ - - - - - - one third
$\frac{1}{2}$ - - - - - - one half
$\frac{2}{3}$ - - - - - - two thirds
$\frac{3}{4}$ - - - - - - three fourths, or three quarters.

17. As decimal fractions are parts of an unit divided into either 10, 100, 1000, 10000, &c. parts, according to the places in the fractional number; therefore they are read like whole numbers, only calling them ſo many parts of 10, or of 100, or of 1000, &c.

Thus a decimal fraction of	one	places, will be ſo many parts of	10, Ten
	two		100, Hundred
	three		1000, Thouſand
	four		10000, Ten thouſand
	&c.		&c.

18. Cyphers on the right hand of integers increaſe their value; on the left hand of a decimal fraction diminiſh its value: But on the left hand of integers, or on the right hand of fractions do not alter their value.

Thus	8 is	8 units	And	0, 8 is	8 parts in 10	of an unit ſo divided.
	80	8 tens		0, 08	8 parts in 100	
	800	8 hundreds		0, 008	8 parts in 1000	

When a fraction has no integer prefixed, it is convenient to put 0 in the place of units.

19. A MIXED NUMBER, is when a fraction is annexed to a whole number.

Thus five and a half is called a mixed number, and is wrote 5 $\frac{1}{2}$, or thus 5, 5; which is thus read, five and five tenths.

20. Like names in different numbers, are ſuch figures as ſtand equally diſtant from the place of units; or have the ſame denominations annexed to them.

Thus all numbers of pounds ſterling are like names, and ſo are all numbers of ſhillings; the like of any numbers of miles, &c.

21. Beſides the decimal notation explained in article 8; there are other kinds in common uſe; ſuch as the *duodecimal*, wherein every ſuperior name contains 12 units of its next inferior name: The *Sexagenary*, or *Sexageſimal*, wherein 60 of an inferior name make one of its next ſuperior. The former is uſed by workmen in the meaſuring of artificers works in building; and the latter is uſed in the diviſion of a *Circle*, and of *Time*.

22. The following characters or marks are frequently uſed in Arithmetical computations, briefly to expreſs the manner of operation.

The mark + (more) belongs to addition; and ſhews that the numbers it ſtands between are to be added together.

Thus 12 + 3, expreſſes the ſum of 12 and 3; or that 3 is to be added to 12, and is thus read, 12 more 3.

The mark – (leſs) is for ſubtraction; and ſhews that the number following it, or on the right hand, is to be taken from the number preceding it, or on the left hand.

Thus 12 — 3, expreſſes the difference between 12 and 3; or that 3 is to be ſubtracted from 12, and is thus read, 12 leſs 3.

The mark × (into) for multiplication, ſhews that the numbers on each ſide of it, are to be multiplied the one by the other.

Thus 12 × 3, denotes the product of 12 into 3; or that 12 is to be multiplied by 3.

Diviſion is expreſſed by ſetting the diviſor under the dividend with a line drawn between them, like a fraction.

Thus $\frac{12}{3}$, expreſſes the quotient of 12 by three; or that 12 is to be divided by 3.

This ſign = (equal) ſhews that the reſult of the operation by the numbers on one ſide of it, is equal either to the numbers on the other ſide, or to the reſult of the operation by theſe numbers.

Thus $12 + 3 = 15$; and $12 - 3 = 9$; and $12 \times 3 = 36$; and $\frac{12}{3} = 4$; ſeverally ſhews the values of the preceding expreſſions.

TABLES

TABLES of ENGLISH MONEY, WEIGHTS and MEASURES.

MONEY.

Farthings	Pence	Shill.	Pound
960 =	240 =	20 =	1 £
48 =	12 =	1s	
4 =	1d		

Note, 1, 2, 3, farthings are thus wrote ¼, ½, ¾.

AVERDUPOIZE WEIGHT.

Drams	Ounces	Pounds	Hund.	Ton
573440 =	35840 =	2240 =	20 =	1
28672 =	1792 =	112 =	1 C	
256 =	16 =	1 lb		
16 =	1 oz			

Note, Proviſions, Stores &c. are weighed by this.

DRY MEASURE.

Pints	Gall.	Pecks	Buſh.	Quarter
512 =	64 =	32 =	8 =	1
64 =	8 =	4 =	1	
16 =	2 =	1		
8 =	1			

Note, 4 buſh. = 1 Comb: 10 qrs. = 1 Wey, 12 Weys = 1 Laſt of Corn.
36 Buſhels = 1 Chaldron of Coals.

TROY WEIGHT.

Grains	pennywt.	ounces	Pound
5760 =	240 =	12 =	1 lb.
480 =	20 =	1 oz.	
gr. 24 =	1 dwt.		

Note, Gold and Silver are weighed by Troy Weight.

WINE MEASURE.

Solid inch	Pints	Gall.	Hogſh.	Pipe	Tun
58212 =	2016 =	252 =	4 =	2 =	1
29106 =	1008 =	126 =	2 =	1 P.	
14553 =	504 =	63 =	1 Hhd.		
231 =	8 =	1			
		42 =	1 Tierce		
		84 =	1 Puncheon		

CLOTH MEASURES.

4 Nails	= 1 Quarter of a Yard
4 Quarters	= 1 Yard.
5 Quarters	= 1 Engliſh ell.
3 Quarters	= 1 Flemiſh ell.
6 Quarters	= 1 French ell.

LONG MEASURE.

Barly corns	Inches	Feet	Yards	Poles	Furl.	Mile
190080 =	63360 =	5280 =	1760 =	320 =	8 =	1
23760 =	7920 =	660 =	220 =	40 =	1	
594 =	198 =	16½ =	5½ =	1		
108 =	36 =	3 =	1			
36 =	12 =	1				
3 =	1					

Alſo 3 miles make 1 League.
And 20 leagues or 60 Sea miles make a degree.
But a degree contains about 69 ½ miles of ſtatute meaſure.
A Fathom = 6 feet = 2 yards,

TIME.

Seconds	Minutes	Hours	Days	Year
31556937 =	525948 =	8766 =	365 ¼ =	1
86400 =	1440 =	24 =	1 da.	
3600 =	60 =	1 ho.		
60 =	1			

Pence Table.

Pence	Sh.	Pence	Pence	Sh.	Pence
20 =	1	8	70 =	5	10
30 =	2	6	80 =	6	8
40 =	3	4	90 =	7	6
50 =	4	2	100 =	8	4
60 =	5	0	110 =	9	2

Even parts of a Pound Sterling.

s	d			d				
10	0	is $\frac{1}{2}$	of a Pound Sterling.	6	is $\frac{1}{2}$	of a Shilling	or $\frac{1}{40}$	of a Pound.
6	8	$\frac{1}{3}$		4	$\frac{1}{3}$		$\frac{1}{60}$	
5	0	$\frac{1}{4}$		3	$\frac{1}{4}$		$\frac{1}{80}$	
4	0	$\frac{1}{5}$		2	$\frac{1}{6}$		$\frac{1}{120}$	
3	4	$\frac{1}{6}$		1½	$\frac{1}{8}$			
2	6	$\frac{1}{8}$		0¾	$\frac{1}{16}$			
2	0	$\frac{1}{10}$						

SECTION II. ADDITION.

ADDITION *is the method of collecting ſeveral numbers into one ſum.*

RULE, 1ſt. Write the given numbers under each other, ſo that like names ſtand under like names; that is, units under units, tens under tens, &c. and under theſe draw a line.

2d. Add up the firſt or right hand upright row, under which write the overplus of the units of the ſecond row, contained in that ſum.

3d. Add theſe units to the ſum of the ſecond row, under which write the overplus of the units of the third row, contained in that ſum.

And thus proceed until all the rows are added together.

EXAMPLES.

Ex. I. *Add* 28 - - - 76 - - - 47 - - - 18 *and* 12 *together.*

Now the numbers being wrote under each other will ſtand thus. Say 2 & 8 is 10, and 7 is 17, and 6 is 23, and 8 is 31; then becauſe 10 units in the right hand row, make an unit in the next row; therefore in 31 there are 3 units of the ſecond row, and an overplus of 1; write down the 1, and add the 3 to the ſecond row, ſaying; 3 that is carried and 1 is 4, & 1 is 5, and 4 is nine, & 7 is 16, and 2 is 18, in which is one unit of the third row (had there been one) and an overplus of 8; write down the 8, and add the 1 to the third row: But as there is no third row, the 1 carried, muſt be wrote on the left hand of the 8; and 181 will be the ſum of the five given numbers.

28
76
47
18
12
―――
181

Ex. II. *Add* 476 - - - 3784 - - - 18329 - - 290 - - 75 - - 7638 - and 46 *together.*

476
3784
18329
290
75
7638
46
―――
The Sum 30638

Ex. III. *Add the numbers.* 10768 - 3489 - - 28764 - - 289 - - 6438 19 *and* 438 *together.*

10768
3489
28764
289
6438
19
438
―――
The Sum 50205

Ex. IV. *Add theſe numbers together.*

3720,45
25,0036
4179,802
3,6284
―――
Sum 7928,8840

Ex. V. *Add the following numbers together.*

15836,071
20,09
34,7
583,27008
―――
Sum 16474,13108

In the two laſt examples, where are integer numbers and fractional numbers, it may be obſerved, that like integer places, and like fractional places ſtand under each other; and the manner of adding them together, is the ſame as explained in the firſt Example.

25. It frequently happens that numbers are to be added together, whoſe names do not increaſe in a tenfold manner as in the laſt Examples; ſuch as in adding different ſums of money, weights or meaſures; in which, regard is to be had to the number of thoſe of a lower name, contained in one of its next greater name, as ſhewn in the preceding tables: Examples of which follow.

Ex. VI. *Add the following ſums of money together.*

£	s	d
353	14	$8\frac{1}{2}$
276	10	4
89	17	$5\frac{1}{4}$
34	12	$10\frac{3}{4}$
754	15	$4\frac{1}{2}$

Ex. VII. *Add the following ſums of money together.*

£	s	d
7683	08	$2\frac{3}{4}$
954	19	$9\frac{1}{2}$
682	10	$7\frac{3}{4}$
63	15	$6\frac{1}{4}$
9384	14	$2\frac{1}{4}$

In theſe two examples, the carriage is by 4 in the farthings; by 12 in the pence; by 20 in the ſhillings, and by 10 in the pounds.

Ex. VIII. *Add the following Troy-Weights together.*

lb	oz	dwt.	gr.
218	10	13	18
176	9	19	23
85	11	17	11
24	8	15	21
506	5	07	01

Carry for 24, 20, 12 and 10

Ex. IX. *Add the following Averdupoize Weights together.*

Tons	C wt.	qrs	lb	oz
535	17	3	22	11
94	19	1	27	13
158	12	0	18	15
7	15	2	13	08
797	05	0	26	15

Carry for 16. 28. 4, 20. 10

Ex. X. *Add the following parts of Time together.*

Weeks	Da.	Ho.	Min.	Sec.
21	4	18	37	59
11	6	13	25	47
19	3	23	59	28
38	4	08	22	39
91	5	16	25	53

Carry for 60. 60. 24. 7. 10

Ex. XI. *Add the following parts of a Circle together.*

Deg.	′	″	‴	iv
176	32	59	43	25
85	59	27	31	59
114	28	45	59	14
67	12	38	24	47
444	13	51	39	25

Carry for 60. 60. 60. 60. 10.

Explanation of Example VI.

Three farthings and 1 farthing is 4 farthings, and 2 farthings is 6 farthings; which is a penny half penny, ſet down $\frac{1}{2}$ and carry 1.

Then 1 and 10 is 11, and 5 is 16, and 4 is 20, and 8 is 28 pence; which is 2 ſhillings and 4 pence; ſet down 4 and carry 2.

Again 2 and 12 is 14, and 17 is 31, and 10 is 41, and 14 is 55 ſhillings; which is 2 pound 15 ſhillings; ſet down 15 ſhillings and carry 2 pound. The reſt is eaſy.

SECTION III. SUBTRACTION.

SUBTRACTION *is the method of taking one number from another, and ſhewing the remainder, or difference, or exceſs.*

The *ſubducend* is the number to be ſubtracted, or taken away.

The *minuend* is the number from which the ſubducend is to be taken.

RULE, 1ſt. Under the minuend write the ſubducend, ſo that like names ſtand under like names; and under them draw a line.

2d. Beginning at the right hand ſide, take each figure in the lower line from the figure ſtanding over it, and write the remainder, or what is left, beneath the line, under that figure.

3d. But if the figure below is greater than that above it, increaſe the upper figure by as many as are in an unit of the next greater name; from this ſum take the figure in the lower line, and write the remainder under it.

4th. To the next name, in the lower line, carry the unit borrowed: And thus proceed to the higheſt denomination or name.

EXAMPLES.

Ex. I.	*From*	436565874	*the minuend.*
	Take	249853642	*the ſubducend.*
	Remains	186712232	*the difference.*

Here the 5 figures on the right of the ſubducend may be taken from thoſe over them: But the 6th figure viz. 8 cannot be taken from the 5 above it. Now as an unit in the 7th place makes 10 in the 6th place, therefore borrowing this unit makes the 5, 15; then ſay 8 from 15 leaves 7, which ſet down; and ſay 1 carried and 9 is 10, 10 from 6 cannot, but 10 from 16 leaves 6, ſet it down; then 1 carried and 4 is 5, 5 from 13 leaves 8, ſet it down: then 1 carried and 2 is 3, 3 from 4 leaves 1.

Ex. II.	*From*	7620908
	Take	3875092
	Remains	3745816

Ex. III.	*From*	327,9563
	Take	49,8697
	Remains	278,0866

Ex. IV.	*From*	30007,295
	Take	2536,876
	Leaves	27470,419

Ex. V.	*From*	5000,
	Take	479,6378
	Leaves	4520,3622

		£	*s*	*d*
Ex. VI.	*Borrowed*	24	14	6 ½
	Paid	18	12	4 ¾
	Remains	6	02	2 ¼

		£	*s*	*d*
Ex. VII.	*Lent*	294	15	9 ¼
	Received	89	18	10 ¾
	Remains	204	16	10 ½

Ex. VIII. *In Sexageſimals.*

	°	′	″	‴	iv
From	76	28	37	49	32
Take	65	29	16	53	45
Leaves	10	59	20	55	47

Ex. IX. *In Sexageſimals.*

	°	′	″	‴	iv
From	218	46	32	50	18
Take	149	52	47	53	29
Leaves	68	53	44	56	49

27 QUESTIONS to exerciſe Addition and Subtraction.

QUEST. I. *The ſhare of Jack's prize money was* 148£. 17 *s.* 6 *d.* ½; *And Tom received as much, beſide* 7£. 18 *s. ſmart money: How much money did Tom receive?*

	£.	s.	d.
Tom's prize money	148	17	6 ½
ſmart money	7	18	0
Tom's ſhare	156	15	6 ½

QUEST. III. *What year was King George born in, he being* 67 *years old in the year* 1749?

Current year	1749
Age	67
Year born in	1682

QUEST. V. *A ſeaman who had received* 46£. 17 *s.* 6 *d. for wages, prize money, &c. meeting with bad company was tricked out of* 18 *guineas: Now John had reckoned to pay his wife's debts of* 13£. 16 *s.* 6 *d. and his landlady's bill of* 16£. 12 *s. Required whether he can fulfil his intentions, and what will the difference be?*

	£.	s.	d.
Money loſt	18	18	0
Wife's debt	13	16	6
Landlady's bill	16	12	0
total	49	6	6
Money received	46	17	6
He will want	2	9	0

QUEST. II. *The Spaniſh invaſion was in the year* 1588, *and the French attempted an invaſion in the year* 1744: *How many years were between theſe fruitleſs attempts?*

French	1744
Spaniſh	1588
Years between	156

QUEST. IV. *Two ſhips depart from the ſame port, one having ſailed* 835 *miles, is got* 48 *miles a-head of the other: Required the aftermoſt ſhip's diſtance?*

The firſt ſhip's diſtance	835
Their difference	48
Second ſhip's diſtance	787

QUEST. VI. *Will and Frank talking of their ages in the year* 1749: *Will ſaid he was born in the year of the Rebellion (in* 1715*), and Frank ſaid he remembered he was ten years old the year King George the ſecond was crowned (in* 1727*): Required the age of each, and the difference of their ages?*

Current year	1749
Will was born	1715
Will's age	34
Current year	1749
King George crowned	1727
Years ſince	22
Frank's age then	10
Frank's age	32

So Will was oldeſt by two years.

28 SECTION IV. MULTIPLICATION.

Multiplication *is the method of finding what a given number will amount to, when repeated as many times as is repreſented by another number.*

The number to be multiplied is called the *Multiplicand.*

The number multiplying by, is called the *Multiplier.*

And the number which the multiplication amounts to, is called the *Product.*

Both Multiplicand and Multiplier are called *Factors.*

Before any operation can be performed in Multiplication, 'tis neceſſary that the learner ſhould commit to memory the following table.

29 The Multiplication Table.

times	2	3	4	5	6	7	8	9	10	11	12
2	4	6	8	10	12	14	16	18	20	22	24
3		9	12	15	18	21	24	27	30	33	36
4			16	20	24	28	32	36	40	44	48
5				25	30	35	40	45	50	55	60
6					36	42	48	54	60	66	72
7						49	56	63	70	77	84
8							64	72	80	88	96
9								81	90	99	108
10									100	110	120
11										121	132
12											14

Obſerve, that in multiplying any figure in the upper line by any figure in the left hand column, the product will ſtand right againſt the figure uſed in the left hand column, and under that uſed in the upper line. Thus was 6 to be multiplied by 9, ſeek the greater figure 9 in the upper line, and right under it, againſt 6 in the left hand, ſtands 54 for the Product. And ſo of others.

The foregoing table being well known, the work of Multiplication will be performed as follows.

To multiply any number,	as	37256
By any ſingle figure,	as by	7
Set them as in the margin and proceed		260792

thus, 7 times 6 is 42, ſet down 2 and carry 4; 7 times 5 is 35 and 4 carried is 39, ſet down 9 and carry 3; 7 times 2 is 14 and 3 carried is 17, ſet down 7 and carry 1; 7 times 7 is 49 and 1 carried is 50, ſet down 0 and carry 5; 7 times 3 is 21 and 5 carried is 26, which ſet down and the work is done. But for compound Multiplication take the following.

30. Rule, 1ſt. Write the Factors ſo, that the right hand place of the Multiplier ſtands under the right hand place of the Multiplicand.

2d. Multiply the Multiplicand ſeverally by every figure of the Multiplier, ſetting the firſt figure of each line under the figure then multiplying by.

3d. Add the ſeveral lines together; and their ſum is the Product.

4th. From the right hand of the Product, point off for fractions, as many places as there are fractional places in both Factors; and thoſe to the left of the mark of diſtinction are integers.

5th. If the number of places in the Product are not as many as the number of fractional places in both Factors, make up that number by cyphers wrote on the left hand, and to theſe prefix the mark of diſtinction.

Exam. I. *Multiply* 742 *by* 53.

Multiplicand	742	Factors.
Multiplier	53	
	2226	
	3710	
Product	39326	

The leſſer Factor being wrote under the greater Factor as here ſhewn, and a line drawn under them; ſay 3 times 2 is 6, write 6 under the 3; then 3 times 4 is 12, write down 2 and carry 1; and 3 times 7 is 21, and 1 carried is 22, write the 22: Again, 5 times 2 is 10, write 0 under the 5, and carry 1; and 5 times 4 is 20 and 1 carried is 21, write down 1 and carry 2; then 5 times 7 is 35, and 2 carried is 37, write down the 37: Now add the two lines together found by multiplying by 3 and by 5, and their ſum 39326 is the Product required.

Example II.

Multiply	28704	
by	8631	
	28704	
	86112	
	172224	
	229632	
	247744224	Product.

Example IV.

Multiply	936,287
by	607,02
	1872574
	65540090
	56177220
	568344,93474

The cyphers in the Multiplier of this example are thus managed. Having multiplied by the 2 as before, ſay 0 times 7 is 0, write 0 under the 0, and proceed to the next figure 7, by which multiply as before; then coming to the ſecond 0, ſay 0 times 7 is 0, write 0 under the place of the ſecond 0, and proceed to the next figure 6, by which multiply as before.

Example III.

Multiply	3684,2795
by	7,594
	147371180
	331585155
	184213975
	257899565
	27978,4185230

Here becauſe there are 4 fractional places in the Multiplicand, and 3 in the Multiplier, which together make 7, therefore 7 places are pointed off on the right of the Product for fractions.

Example V.

Multiply	0,34796
by	0,0258
	278368
	173980
	69592
	0,008977368

Here becauſe there are 5 fractional places in one Factor, and 4 in the other, there ſhould be 9 fractional places in the Product; and there ariſing but 7, therefore 2 cyphers are ſet on the left hand to make 9 places.

SECTION V. DIVISION.

31. DIVISION *is the method of finding how often one number is contained in another ; or, may be taken from another.*

The number to be divided, is called the *Dividend.*

The number dividing by, is called the *Diviſor.*

The *Quotient* is the number ariſing from the diviſion, and ſhews how many times the Diviſor is contained in the Dividend.

The operations in Diviſion are performed as follow.

32. RULE, 1ſt. On the right and left of the Dividend draw a crooked line; write the Diviſor on the left-ſide, and the Quotient as it ariſes, on the right ſide of the Dividend.

2d. Seek how often the Diviſor may be taken in as many figures on the left hand of the Dividend, as are juſt neceſſary ; write the number of times it may be taken, in the Quotient ; and there will be as many figures more in the Quotient, as there are figures remaining in the Dividend then not uſed.

3d. Multiply the Diviſor by this Quotient-figure, ſet the Product under that part of the Dividend uſed ; ſubtract, and to the right hand of the remainder bring down the next figure of the Dividend : Divide as before ; and thus proceed until all the figures of the Dividend are uſed.

4th. If there is a Remainder, to its right hand ſide annex a cypher or cyphers, as if brought down from the Dividend, and divide as before ; and thus it is that fractions ariſe, *viz.* from the Remainders in Diviſion.

5th. When any figure of the Dividend is taken down, or annexed, as before ſhewn, and the diviſion cannot be taken in the number thus increaſed ; put 0 in the Quotient, and take down, or annex, another figure ; and proceed in like manner till the Diviſor can be taken from the number.

6th. When fractions are concerned : From the number of fractional places uſed in the Dividend, take thoſe in the Diviſor ; count the number of remaining places from the right of the Quotient, put the mark there ; and thoſe to the left are integers, thoſe to the right fractions.

7th. If there ariſe not ſo many places in the Quotient as the 6th article requires ; ſupply the places wanting with cyphers on the left ; and to theſe prefix the fractional mark.

Ex. I. *Divide* 3656 £. *among* 8 *perſons.*

Set the given number as in Art 1ſt. Now the two left hand figures contain 8 ; then ſay 8 is contained in 36, 4 times ; ſet 4 in the Quotient, and ſay 4 times 8 is 32, ſet 32 under 36, ſubtract, there remains 4, to which bring down the next figure of the Dividend 5, makes 45 ; then ſay 8 is contained in 45, 5 times ; ſet 5 in the Quotient, and ſay 5 times 8 is 40 ; write 40 under 45, ſubtract, and to the Remainder 5, take down 6, the next figure of the Dividend, makes 56 ; then ſay 8 is contained in 56, 7 times ; write 7 in the Quotient, multiply 8 by 7 makes 56, which wrote under the other 56, and ſubtracting there remains 0 : So it may be concluded that 3656 contains 8, 457 times : Or if 3656 £. be divided among 8 perſons, the ſhare of each would be 457 £.

```
8)3656(457
  32
  --
   45
   40
   --
    56
    56
    --
     0
```

Ex. II. *Divide* 3125 *by* 25.

```
25) 3125 (125
    25
    --
     62
     50
     --
     125
     125
     ---
       0
```

Ex. IV. *Divide* 5859 *by* 124.

```
124) 5859 (47,25
     496
     ---
      899
      868
      ---
       310 for the Remaind.
       248 ſee precept 4th.
       ---
        620
        620
        ---
```

Ex. VI. *Divide* 2,3569 *by* 673,4.

```
673,4) 2,3569 (35
       20202   Quot. 0,0035
       -----
        33670  ſee precepts
        33670  4th. 6th. 7th.
        -----
```

Ex. III. *Divide* 95269 *by* 47.

```
             47) 95269 (2027
                 94
                 --
ſee precept       126
5th.               94
                  ---
                  329
                  329
                  ---
                    0
```

Ex. V. *Divide* 337,27368 *by* 6,28.

```
         6,28) 337,27368 (53,706
               3140   for the Quotient
               ----   ſee precept 6th.
                2327
                1884
                ----
                 4433
                 4396
                 ----
ſee precept 5th   3768
                  3768
                  ----
```

In Ex. 6th. the 4 fractional places given in the Dividend, and the 0, uſed with the Remainder make 5 fractional places; from which 1 place in the Diviſor being taken leaves 4 fractional places for the Quotient; but in the Quotient are only the two places 35, therefore 2 cyphers are prefixed, and makes, ,0035, before which for form ſake, an 0 is ſet for the place of units.

33. When the Diviſor does not exceed the number 12, the Diviſion may be performed in one line; by making the Multiplication and Subtraction mentally, or in the mind, and carrying the Remainder, as ſo many tens, to the next figure.

34. In all operations of Diviſion, it muſt be obſerved, that the Product of the Diviſor by the Quotient-figure muſt not exceed that part of the Dividend then uſing; and the Remainder, by ſubtracting the Product, muſt ever be leſs than the Diviſor,

As the Quotient multiplied by the Diviſor makes the Dividend;

So the Product of two numbers being divided by one of them, will give the other: that is, Diviſion is proved by Multiplication, and Multiplication is proved by Diviſion.

SECTION

SECTION VI. REDUCTION.

35. Reduction *is the method of reducing numbers from one name, or denomination, to another; retaining the ſame value.*

Case I. *To reduce a number conſiſting of ſeveral names, to their leaſt name.*

Rule, 1ſt. Multiply the firſt, or greater name, by the parts which an unit thereof contains of the next leſs name; adding to the Product the parts of the ſecond name in the given number.

2d. Multiply this ſum by the parts that an unit thereof contains of the next leſs name; adding to the Product the parts of the third name contained in the given number: And thus proceed, until the leaſt name in the given number is arrived at.

Ex. I. *In* 23£. 14*s.* 6½*d. how many farthings?*

£. *s.* *d.*
23 14 6½
20

474 Shillings
12

5694 Pence
4

Anſwer 22778 Farthings.

Ex. II. *In* 8 *lb.* 10 *oz. of gold, how many grains?*

lb. oz.
8 10
12

106 Ounces
20

2120 Pennyweights
24

8480
4240

50880 Grains.

Ex. III. *In a cannon weighing* 2 *Tons,* 14 *C.* 3 *qrs.* 19 *lb. how many pounds?*

T. C. Qrs. lb.
2 14 3 19
20

54 C. weight
4

219 Qrs.
28

1771
438

6151 Pounds.

Ex. IV. *In* 36 *deg.* 48′. 27″. 56‴. *how many thirds?*

° ′ ″ ‴
36 48 27 56
60

2208 Minutes
60

132507 Seconds
60

7950476 Thirds.

An explanation of the firſt Ex. will make all the reſt plain. Since pounds is the greateſt name in the given number, and an unit thereof contains 20 of the next leſs name, or ſhillings; therefore multiply the pounds by 20, ſaying 0 times 3 is 0, to which adding the 4 in the 14s. makes 4; then 2 times 3 is 6, and the 1, in the place of tens in the ſhillings, make 7; then 2 times 2 is 4: Now multiply 474s. by 12, ſaying 12 times 4 is 48, and the 6 in the pence make 54, write 4 and carry 5; then 12 times 7 is 84 and 5 is 89 &c. Laſtly, multiply the 5694 pence by 4, ſaying 4 times 4 is 16, and the 2 farthings in the given number is 18, write 8 and carry 1 &c.

36. Case II. *A number of an inferior name being given; to find how many of each ſuperior denomination are contained therein.*

Rule 1ſt. Divide the given number, by ſuch a number thereof, as makes one of the next ſuperior name.

2d. Divide this Quotient by the parts making one of the next name.

3d. Divide this Quotient by the parts making one of the next name: And proceed in this manner until the higheſt name is obtained.

4th. Then the laſt Quotient, and the ſeveral Remainders, will be the parts of the different names contained in the given number.

Ex. I. *In* 22778 *farthings, how many £. S. D?*

4)	22778	2 Farthings
12)	5694	6 Pence
2,0)	47,4	14 Shillings
	23	Pounds.

Anſwer 23 £. 14 *s*, 6½ *d.*

Ex. II. *In* 7950476 *thirds of a degree, how many* ° ′ ″ ‴.

6,0)	795047,6	56 Thirds
6,0)	13250,7	27 Seconds
6,0)	220,8	48 Minutes
	36	Degrees.

Anſwer 36°. 48′. 27″. 56‴.

Ex. III. *In* 6151 *pounds, how many Tons, C. Qrs. lb.?*

28) 6151 (219		
56	4) 219	3 Qrs.
55	2,0) 5,4	14 C.
28	2	Tons.
271		
252		
19 Pounds.		

Anſwer 2 T. 14 C. 3 Qrs. 19 lb.

Ex. IV. *In* 50880 *grains, how many lb. oz. dwt. gr.*

24) 50880 (2120		
48	2,0) 212,0	0 dwt
28	12) 106	10 oz.
24	8	lb.
48		
48		
0		

Anſwer 8 lb. 10 oz.

Explanation of Ex. I. Since 4 of the given number, make one of the next name, pence; then 22778 divided by 4, give 5694 pence, and a Remainder of 2 farthings; then 5694 pence divided by 12, the number of pence in one of the next name, ſhillings, the Quotient is 474 ſhillings, and a Remainder of 6 pence; then 474 ſhillings divided by 20, the number of ſhillings in one of the next name, pounds, the Quotient is 23 pounds, and a Remainder of 14 ſhillings. And by the 4th precept the anſwer is collected.

A like operation will ſolve the other examples, having regard to the increaſe of the different names.

37. In any Diviſion, if the Diviſor has one or more cyphers on the right hand, thoſe cyphers may be pointed off; but then as many places muſt be pointed off from the Dividend, which places are not to be divided, but reckoned with the Remainder. See the above examples.

38. CASE III. *To reduce a vulgar fraction to its equivalent decimal fraction.*

RULE. To the Numerator annex one or more cyphers, divide this by the Denominator, and the Quotient will be the fraction ſought.

If the Diviſion does not end when ſix figures are found in the Quotient, the work need not be carried any farther.

EXAM. I. *To reduce* $\frac{15}{423}$ *to it equal decimal fraction.*

423) 15,00(0,03546
1269
2310
2115
1950
1692
2580
2538
420

Here 423 the Denominator is made the Diviſor, and 15 the Numerator is ſet for the Dividend, to which annexing a cypher or two for fractional places, ſeek how often the Diviſor can be had in 15 the integral part of the Dividend; and as it cannot be taken, put 0 in the Quotient for the place of units: Then taking in one fractional place, ſeek how oft the Diviſor can be had in 150, ſay 0 times, and put another 0 in the Quotient for the place of primes: Now taking in two fractional places to the 15, the Diviſor will be contained therein thrice, and thus proceed until the Diviſion ends, or till 6 places ariſe in the Quotient: But in this example, as the 6th place would be 0, it is omitted, becauſe cyphers on the right hand of decimal fractions are of no ſignification, as will evidently appear, Notation of Fractions being well underſtood.

Ex. II. *Reduce* $\frac{1}{2}$ *to a decimal fraction.*
2) 1,0 (0,5 Anſwer.

Ex. III. *Reduce* $\frac{1}{4}$ *to a decimal fraction.*
4) 1,00 (0,25 Anſwer.

Ex. IV. *Reduce* $\frac{3}{4}$ *to a decimal fraction.*
4) 3,00 (0,75 Anſwer.

Ex. V. *Reduce* $\frac{5}{8}$ *to a decimal fraction.*
8) 5,000 (0,625 Anſwer.

Ex. VI. *Reduce* $\frac{2}{3}$ *to a decimal fraction.*
3) 2,00 (0,33 &c. Anſwer.

Ex. VII. *Reduce* $\frac{7}{12}$ *to a dec. fraction.*
12) 7,0000 (0,5833 &c. Anſ.

In the two laſt Quotients, it may be obſerved that 3 would continually ariſe; ſuch decimal fractions are called circulating or recurring fractions: Theſe have a peculiar kind of operation belonging to them, which the inquiſitive reader will find in a little book called *A General Treatiſe of Menſuration* publiſhed in the year 1748; and alſo in other books.

40. CASE IV. *To reduce a number conſiſting of different names, to a decimal fraction of its greateſt name.*

RULE, 1ſt. Write the given names orderly under one another, the leaſt name being uppermoſt; and on their left ſide draw a line: Let theſe be reckoned as Dividends.

2d. Againſt each name, on the left hand, write the number making one of its next ſuperior name: And let theſe be the Diviſors to the former Dividends.

3d. Begin with the upper one, and write the Quotient of each diviſion as fractions, on the right of the Dividend next below it; then let this mixed number be divided by its Diviſor, &c.

And the laſt Quotient will be the fraction ſought.

Ex. I. *Reduce* 15 *s.* 9$\frac{3}{4}$ *d. to the fractional part of a pound ſterling.*

4	3
12	9,75
20	15,8125
	0.790625

Firſt ſet the three farthings, the 9 pence, the 15 ſhillings and 0 pounds under one another; and againſt the farthings ſet 4, againſt the pence ſet 12, and againſt the ſhillings, 20; then the 3, with 0^s. ſuppoſed to be annexed, being divided by 4, the Quotient ,75 is wrote on the right hand of the 9 pence; and the mixed number 9,75 with 0s. annexed as they are wanted, being divided by 12, the Quotient ,8125 is wrote on the right hand of the 15 s. then this mixed number 15,8125 being divided by 20, the Quotient 0,790625 £. is the anſwer.

Ex. II. *Reduce* 1 *s.* 2$\frac{1}{4}$ *d. to the fractional part of a pound ſterling.*

4	1
12	2,25
20	1,1875
	0,059375

Anſwer 1 *s.* 2 *d*$\frac{1}{4}$=0,059375 £.

Ex. IV. *Reduce* 8 *oz.* 15 *dwt.* 18 *gr. to the fractional part of a pound troy.*

24	4	18
	6	(4,5
20		15,75
12		8,7875
		0.732291

Anſ. 8 oz. 15 dwt. 18 gr.=0,732291 lb.

41. Here becauſe 24 is a number too great to divide by in one line, therefore it is broke into the parts 4 and 6, which multiplied together make 24.

Ex. III. *Reduce* $48'$. $17''$. $53'''$. *to the fractional part of a degree.*

60	53
60	17,883333
60	48,298055
	0,804967

Anſ. $48'$. $17''$. $53'''$.=0,804967 Deg.

Ex. V. *Reduce* 3 *qrs.* 19 *lb.* 14 *oz. to the fractional part of a C. weight.*

16	4	14
	4	(3,5
28	4	19,875
	7	(4,96875
4		3.709821
		0,927455

Anſ. 3 qr. 19 lb. 14 oz.=0,927455 C.

Here the 16 is broke into the numbers 4 and 4; and 28, into 4 and 7; and 14 is divided by 4; and the Quotient 3,5 by 4, &c.

42. Case V. *To reduce a decimal fraction of a ſuperior name, to its value in inferior denominations.*

Rule, 1ſt. Multiply the given fraction by the number that an unit of its name, contains units of the next leſſer name; from the right hand of the Product point off as many places as are in the given fraction.

2d. Multiply the places ſo pointed off, by as many as an unit of this name, contains of the next leſs name; point off as before.

And thus proceed until the multiplication is made by the leaſt name.

3d. Then the integers, or the numbers on the left of the diſtinguiſhing marks in each Product, will be the parts in each name, which together are equal to the given fraction.

Ex. I. *What number of ſhillings, pence, and farthings are equal in value to* 0,790625 *£. ſterling?*

Here an unit of the given name £, contains 20 of the next leſs name ſhillings, then multiplying by 20, and pointing off 6 places on the right, becauſe the given number 0,790625 contains 6 fractional places, the Product is 15,812500 ſhillings; then the fractions of this number, *viz.* 812500 multiplied by 12, the number that an unit of this name contains of the next leſs name, and the Product pointed as before, there ariſes 9,750000 pence; the fractions of this number multiplied by 4, gives 3,000000 farthings; then the parts pointed off on the left, *viz.* 15 s. 9¾d. are the value of the given fraction.

£. 0,790625
20
s. 15,812500
12
d. 9,750000
4
far. 3,000000

Example II. *What is the value of* 0,056285 *£. ſterling?*

£. 0,056285
20
s. 1,1257|00
12
d. 1,5084
4
far. 2,0336

Example III. *What is the value of* 0,58695 *degree?*

Deg. 0,58695
60
Min. 35,217|00
60
Sec. 13,02|0
60
Thirds 0,120

Example IV. *What is the value of* 0,732291 *lb. troy?*

This example worked as above by multiplying by 12, 20, 24, the value will be found to be
8 oz. 15 dwt. 18 gr. nearly.

Example V. *What is the value of* 0,927455 *part of a C. weight?*

By operating as above, multiplying by 4, 28, 16, the anſwer will be
3 qrs. 19 lb. 14 oz. nearly.

43 QUESTIONS to exercise the preceding rules.

QUEST. I. *A ſloop with the captain and 26 hands take a prize which ſold for 1578 £. whereof each ſeaman had 45 £. and the captain the reſt: How much was his ſhare?*

26 Men.
45 £. to each.

130
104

ſubtract 1170 £. the crew's ſhare
from 1578 £. the whole prize

remains 408 £. the captain's ſhare.

QUEST. II. *A boat's crew of 15 men got by plunder 321 £: How much was the ſhare of each?*

15) 321 (21 £.
30

21
15

remains 6 £. which
mult. by 20 s. in 1 £.

15) 120 s. (8 s.
120

Anſwer 21 £. 8 s. to each.

QUEST. III. *A ſeaman whoſe wages is 35 s. 6 d. a month, returns home at the end of 29 months; he having taken up 12 £. 18 s: How much has he to receive?*

s. d.
35 6
mult. by 12

426 pence a month
mult. by 29 months

3834
852

12) 12354 pence.

2,0) 102,9 6 d.

from 51 £. 9 s. 6 d. = wages
take 12 £. 18 s. 0 d. received

remains 38 £. 11 s. 6 d. to receive

QUEST. IV. *Six meſs-mates, who propoſe to live well during an Eaſt India voyage of 22 months, agree to expend among them 5 s. a day, beſides the ſhip's allowance: Now one of them having but 25 s. a month, how will matters ſtand with him at the end of the voyage?*

Now 28 days at 5 s. a day, makes 140 s. or 7 £. a month; which for 22 months, is 154 £.

Then a ſixth part of 154 £. is 25 £. 13 s. 4 d. for each man.

Alſo 25 s. a month for 22 months, makes 27 £. 10 s. for wages; which will over-pay his expences, by 1 £. 16 s. 8 d.

QUEST. V. *In 306 crowns, how many half crowns and pence?*

Anſwer { 612 half crowns
18360 pence.

QUEST. VI. *In 30 chalders of coals, each of 36 buſhels, how many pecks?*

Anſwer 4320 pecks.

QUEST. VII. *A ſeaman's ſhare of a prize was 14 guineas, 32 moidores, 12 thirty-ſix ſhillings pieces, and 52 piſtoles at 17 s. each: How much ſterling did the whole come to?*

Anſwer 123 £. 14 s.

QUEST. VIII. *Suppoſe a ſhip ſails 5½ miles an hour for 14 days: How many degrees and minutes has ſhe ſailed in the whole; 60 ſea miles making one degree?*

Anſwer 30 deg. 48 min.

SECTION VI. Of PROPORTION.

Or, THE RULE OF THREE.

44. Four numbers are ſaid to be proportional, when by comparing them together by two and two, they either give equal Products or equal Quotients.

Suppoſe theſe four numbers 3 8 12 32
In comparing them together by multiplication.

The Product of 3 and 8 is 24; of 12 and 32 is 384, unequal.
of 3 and 12 is 36; of 8 and 32 is 256, unequal.
of 3 and 32 is 96; of 8 and 12 is 96, equal.

Therefore 3 8 12 32, are called proportional numbers.
Now let them be compared together by diviſion.

The Quotient of 8 by 3 is 2,6 *&c.* of 32 by 12 is 2,6 *&c.* equal.
of 12 by 3 is 4 of 32 by 8 is 4, equal.
of 32 by 3 is 10,6 *&c.* of 12 by 8 is 1,5, unequal.

Therefore by this compariſon, the numbers are ſaid to be proportional.

In this kind of comparing four numbers together, there is no need to try for more equal Products, or Quotients, than one ſet of either ſort; for either caſe will determine the proportionality independent of the other.

But it muſt be obſerved, that among four proportional numbers, there will be but one ſet of equal Products; and two ſets of equal Quotients, the ſmaller numbers being Diviſors.

45. When four numbers are to be wrote as proportionals, they muſt be placed in ſuch order, that the Product of the firſt and fourth be equal to the Product of the ſecond and third.

A queſtion is ſaid to belong to the *Rule of Three*, when three numbers or terms are given to find a fourth proportional, which is the anſwer to the queſtion.

And in order to reſolve ſuch queſtions, the three given terms muſt be firſt placed in a proper order, which is called ſtating the terms of the queſtion.

46. Queſtions in the *Rule of Three* are ſtated, and reſolved by the following precepts.

1ſt. Conſider of what kind the fourth term, or number ſought will be, whether money, weight, meaſure, time, *&c.* and among the three numbers given in the queſtion, let that which is of the ſame kind with what is required, be placed for the third term.

2. From the nature of the queſtion, determine whether the number ſought will be greater or leſs than the number which is placed for the third term.

3d. If the fourth term will be greater than the third, ſet the greater of the remaining two terms for the ſecond, and the leſſer for the firſt.

But if the fourth term is to be leſs than the third, ſet the greater of the remaining two terms for the firſt, and the leſſer for the ſecond.

Then in either caſe, the given three terms are ſtated.

4th. Reduce thoſe terms which conſiſt of more names than one, to one name; and obſerve that the firſt and ſecond terms are always to be of the ſame name.

5. Multiply the ſecond and third terms together, divide the Product by the firſt term, and the Quotient will be the fourth term, of the ſame name the third term was reduced to.

47. QUEST. I. *If* 4 *yards of cloth coſt* 18 *s. what will* 24 *yards coſt?*

Here it is plain, that the term ſought or the worth of 24 yards, will be money; therefore the given money 18 s. is ſet for the third term; and as the worth of 24 yards muſt be greater than the worth of 4 yards, therefore the 24 is ſet for the 2d. term, and the 4 for the 1ſt. Then the 2d. term 24 being multiplied by the 3d. 18, the Product is 432, which divided by the 1ſt. term 4, the Quotient or 4th term is 108, which are ſhillings, the ſame name of the 3d. term; then 108 ſhillings divided by 20, gives 5 £. 8 *s.*

```
yds.  yds.    s.
 4     24     18
       18
      ----
      192
      24
      ----
   4) 432 (108 ſhillings.
      ---  ---
     2,0) 10,8 ſhillings.
          ----
            5  Pounds.
Anſwer 5 £. 8 s.
```

QUEST. II. *If I lend* 200 £. *for* 12 *months, how long ought I to have the uſe of* 150 £. *to recompence me?*

Here the anſwer or 4th term is to be time; therefore let 12 months, the given time, be ſet for the 3d. term: Now it is evident that the 150 £. being leſs than the 200 £. muſt be kept a longer time, and ſo the 4th term will be greater than the 3d. term: Therefore the 200 is put for the 2d. term, and the 150 for the 1ſt. Then the 2d. term multiplied by the 3d. the Product will be 2400; which being divided by the 1ſt. term, the Quotient 16 is the 4th term; and becauſe the 3d. term was months, the 4th term will be months.

```
 £.     £.      m.
150    200      12
        12
       ----
15,0)  240,0 (16 months.
       15
       ---
        90
        90
       ---
Anſwer 16 months.
```

QUEST. III. *What will* 1836 *lb. of raiſins come to, at the rate of* 6 *s.* 8 *d. for* 24 *lb.*

Here as money is the thing ſought, money muſt be the 3d. term: And as 6 *s.* 8 *d.* conſiſts of two names, they muſt be reduced to one name, *viz.* pence.

lb.	*lb.*	*s.*	*d*
24	1836	6	8

6 8
1836 12
80
80 pence
24) 146880 (6120 pence
144
12)6120
28
24 2,0) 51,0 10 *s.*
25 £.
48
48
00

Here the 2d. term being multiplied by the 3d. and the Product divided by the 1ſt. the Quotient is 6120 pence; which being valued gives 25 £. 10 *s.*

QUEST. IV. *If* 20 *yards of cloth* 5 *quarters wide will ſerve to hang a room: How many yards of* 4 *quarters wide will ſerve to hang the ſame room?*

Here yards of length are required; then 20 yards muſt be the 3d. term.

qrs.	qrs.	yds.
4	5	20

5
4) 100 (
Anſwer 25 yards.

QUEST. V. *What will* 420 *yards of cloth come to at* 14 *s.* $10\frac{3}{4}$ *d. for* 1 *ell engliſh?*

The term ſought being money, the 14 *s.* $10\frac{3}{4}$ *d.* muſt be the 3d. term, and be reduced to farthings: Alſo the 1ſt. and 2d. terms are to be reduced to quarters of yard.

Ell Eng.	*yds.*	*s.*	*d.*
1	420	14	$10\frac{3}{4}$

1 420 14 $10\frac{3}{4}$
5 4 12
5 1680 178
715 4
8400 715 farth.
1680
11760
5) 1201200 (
4) 240240 farthings
12) 60060 pence
2,0) 500,5 05 s.
250 £.
Anſwer 250 £. 5 *s.*

The Diviſor 5 being a ſingle digit, the Quot. is wrote under the Div.

QUEST. VI. *A owes to B* 463 £. *but compounds for* 7 *s.* 6 *d. in the pound: How much muſt B receive for his debt?*

Here compoſition money is the thing ſought; then the 3d. term muſt be the compoſition money, *viz.* 7 s. 6 d.

£.	£.	*s.*	*d.*
1	463	7	6

90 12
12) 41670 6 d. 90 pence
2,0) 347,2 12 s.
173
Anſwer 173 £. 12 *s.* 6 *d.*

48. As it will be more convenient in moſt caſes to reduce ſuch numbers or terms which conſiſt of ſeveral names to the fractional parts of their greateſt name, than to reduce them to their loweſt name; therefore in the ſolution of ſome of the following queſtions, the inferior parts of the given terms, are reduced by caſe IV. of Reduction; and the anſwers are valued by caſe V.

Quest. VII. *If* 8 *lb. of pepper coſt* 4 *s.* 8 *d: What will* 7 *C.* 3 *qrs.* 14 *lb. come to at that rate?*

lb.	C.	qrs.	lb.	s.	d.
8	7	3	14	4	8

4

31

28

262

62

882

12

56

882 lb.

56

5292

4410

8) 49392 (

12) 6174 6d

2,0) 51,4 14s

25 £.

Anſwer 25 £. 14 *s.* 6 *d.*

Quest. IX. *What is the intereſt of* 584 *£. for a year, at* 5 *per cent. per annum: Or at the rate of* 5 *£. for the uſe of* 100 *£. for a year?*

Here intereſt is the term required: therefore 5 £. the intereſt of 100 £. is to be the 3d. term: And as the 4th term, or the intereſt of 584 £. is greater than the 3d. term; then the 2d. term is to be greater than the 1ſt.

£.	£.	£.
100	584	5

5

1,00) 29,20 (See Caſe V. of Reduction.

20

4,00

Anſwer 29 £. 4 *s.*

Quest. XI. *What is the intereſt of* 542 *£.* 10 *s. for* 219 *days, at* 5 *£. per cent. per annum?*

To ſolve this queſtion, find the intereſt for 1 year; multiply this intereſt by 219 and divide the Product by 365; the Quotient will be the anſwer; and is 16 £. 5 *s.* 6 *d.*

Quest. VIII. *One bought* 4 *Hhds. of ſugar, each containing* 6 *C.* 2 *qrs.* 14 *lb. at* 2 *£.* 8 *s.* 6 *d. for each C. weight: What did the whole come to?*

C.	C.	qrs.	lb.	£.	s.	d.
1	6	2	14	2	8	6

Now 1 C. weight is 112 lb.
And 4 Hh. at 6 C. 2 q. 14 b. = 2968 lb.
Alſo 2 £. 8 *s.* 6 *d.* is 582 *d.*
Then the Product of the 2d. and 3d. terms is 1727376.
Which divided by the 1ſt. term 112, the Quotient is 15423 pence, whoſe value is 64 £. 5 *s.* 3 *d.*

Quest. X. *What is the intereſt of* 387 *£.* 12 *s. for* 3 *years and* 4 *months, at* 3½ *per cent, per annum?*

Find the intereſt for 1 year; then thrice that, together with ⅓ of one year, will be the intereſt ſought.

£.	£.	£.
100	387,6	3,5

3,5

19380

11628

100) 1356,60 (

£. 13,566 for 1 year.

3

40,698 for 3 years

⅓ of 1 year = 4,522 for 4 months.

45,220

Anſwer 45 £. 4 *s.* 5 *d.*

Quest. XII. *For how long muſt* 487 *£.* 10 *s. be at ſimple intereſt at* 4⅓ *£. per cent. per annum, to gain* 95 *£.* 1 *s.* 3 *d.?*

Find what will be the intereſt of 487 £. 10 *s.* for 1 year; divide 95 £. 1 *s.* 3 *d.* by this intereſt, and the Quotient will be 4½ years.

QUEST. XIII. *One bought 14 pipes of wine, and is allowed 6 months credit: But for ready money gets it 6 d. in a gallon cheaper: How much did he ſave by paying of ready money?*

Anſwer 44 £. 2 s.

QUEST. XV. *One bought 3 tons of oyl for 153 £. 9 s. which having leaked 74 gallons, he would make the prime-coſt of the remainder: How muſt it be ſold per gallon?*

Now 1 T. = 252 Gall. And 3 T. = 756
Subtract the gallons leaked = 74

Remains 682

	G.	£.	G.
Then	682	153,45	1

Anſwer 4 s. 6 d. a gallon.

QUEST. XVII. *At 13 £. for 100 lb. of goods: What will 895 lb. come to allowing 4 lb. upon every 100 lb. for tret, or waſte?*

Since 4 lb. is to be allowed on the 100 lb. therefore 104 lb. is given for 100.

	lb.	lb.	£.
Then	104	895	13

Anſwer 111 £. 17 s. 6 d.

QUEST. XIX. *If 100 pounds of ſugar be worth 36 s. 8 d: What will be the worth of 875 lb. rebating 4 lb. upon every 100 lb. for tare?*

Here the buyer has 100 lb. on paying for 96 lb.

	lb.	lb.	lb.
Then	100	96	875

And the 4th term will be 840 lb.

	lb.	lb.	£.
Alſo	100	840	1,833333

Then the 4th term will be 15 £. 8 s. and ſo much will the ſugar come to.

QUEST. XIV. *A clothier ſold 50 pieces of Kerſey, each piece containing 34 ells Flemiſh, at the rate of 8 s. 4 d. per ell Engliſh: What did the whole come to?*

Anſwer 425 £.

QUEST. XVI. *A broker ſold $\frac{2}{5}$ of $\frac{3}{4}$ of a ſhip for 147 £. 11 s. 3 d: How much was the whole ſhip valued at?*

Now $\frac{2}{5}$ of $\frac{3}{4} = \frac{6}{20} = 0,3$.
And 147 £. 11 s. 3 d. = 147,5625 £.

	ſhare	ſhare	£.
Then	0,3	1	147,5625

Anſwer 491 £. 17 s. 6 d.

QUEST. XVIII. *One has cloth which coſt 2 s. 8 d. a yard: For how much muſt it be ſold a yard on 3 months credit, to gain 25 £. per cent. per annum?*

	mon.	mon.	£.	£.
Firſt	12	3	25	6,25

	£.	£.	£.
Secondly	100	6,25	0,133333

By multiplying and dividing, the 4th term will be found 2 d.
Then 2 s. 8 d. + 2 d. = 2 s. 10 d. a yard the ſelling price.

QUEST. XX. *A chapman bought 81 Kerſeys for 135 £. How muſt he ſell them per piece to gain 15 £. per cent.?*

Find how much 135 £. will be advanced to at 15 £. per cent.

Then this ſum divided by 81 will be the ſelling price of each piece.

	£.	£.	£.	£.
Now	100	115	135	155,25.

Then 81) 155,25 (1,916666 £.
Anſwer 1 £. 18 s. 4 d. a-piece.

QUEST. XXI. *A merchant who is to receive a ſum of money, is offered ducats at 6 s. 4 d. which are worth but 6 s. 2½ d. or chequins at 8 s. 2 d. each, that are worth but 8 s.: By which ſpecie will he ſuſtain the leaſt loſs?*

6 s. 2½ d. =74,5 d. } the real value.
8 s. 0 =96
6 s. 4 =76 d. } the advan. val.
8 s. 2 d. =98

	r. val.	r. val.	ad. va.	ad. va.
Then	74,5	96	76	97,93.

But the chequins are valued at 98 d. Therefore the ducats are moſt advantageous.

QUEST. XXII. *One who had ſold a parcel of cloths at 2 s. 10 d. a yard on 3 months credit, found he had gained 25 £. per cent. per annum: What did the cloth coſt per yard?*

	mo.	£.	mo.	£.
Now	12	25	3	6,25

And 100+6,25=106,25 £.

	£.	£.	£.
Then	106,25	100	0,14166

The fourth term to which will be a fraction whoſe value will be 2 s. 8 d. which is the prime-coſt per yard of the cloth.

QUEST. XXIII. *A perſon wants 750 pieces of foreign coin, each worth 11 s. 4 d. How much will they come to, allowing the broker the worth of 2 pieces upon every 100?*

Now 100 102 750 765
He muſt pay for 765 pieces, which will come to 433 £. 10 *s*

QUEST. XXIV. *A gentleman would exchange 729 pieces of 4 s. 2 d. each into ſterling money: How much will he receive for them, allowing the broker 1¼ £. per cent.?*

	P.	P.	£.	£.
Now	1	729	0,208333	151,875

the worth of the pieces.
Then 101.25 100 151.875 150£.
He will receive 150 £. for them.

QUEST. XXV. *A grocer bought 4¼ C. of pepper for 15 £. 17 s. 4 d. which proving to be damaged he is willing to loſe 12½ £. per cent. For how much muſt he ſell it a lb.?*

Since he is to loſe 12½ per cent. he muſt take 87 £. 10 *s.* for 100 £. Now diminiſh the 15 £. 17 *s.* 4 *d.* in this proportion, and this ſum divided by the pounds in 4¼ C. will give 7 *d.* for what each pound is to be ſold at.

QUEST. XXVI. *Suppoſe 42 gallons of honey be valued at 2 £. and the duty is 15 £. per cent. on this value, and a draw back of 5 £. per cent. on the duty for prompt payment: What will the ready money duty of 672 gallons come to?*

Now	42	2	672	32 £.
And	100	15	32	4,8 £.
Alſo	100	95	4,8	4,56£.

Anſwer 4 £. 11 *s.* 2½ *d.*

The Rule of Proportion is of almoſt univerſal uſe in all buſineſs where computation is required; as in buying and ſelling; values of ſtocks and their dividends; the intereſt and diſcount of money; the cuſtoms and duties on goods &c. But the deſigned brevity of this book will not permit farther illuſtrations.

SECTION VII. OF THE POWERS OF NUMBERS AND OF THEIR ROOTS.

49. *The* Power *of a number, is a product ariſing by multiplying that number by itſelf, the product by the ſame number, this product by the ſame number, &c. to any number of multiplications.*

The given number is called the firſt power, or root.
The Product of the 1ſt. power by itſelf, is the 2d. power, or ſquare.
The Product of the 2d. power by the 1ſt. is the 3d. power, or cube.
The Product of the 3d. power by the 1ſt. is the 4th. power, *&c.*

50. Here follows the 1ſt. 2d. and 3d. powers of the nine digits.

Roots, or 1ſt. power	1	2	3	4	5	6	7	8	9
Squares, or 2d. power	1	4	9	16	25	36	49	64	81
Cubes, or 3d. power	1	8	27	64	125	216	343	512	729

Ex. I. *What is the 2d. power, or ſquare of the number* 24*?*

24×24=576 is the 2d. power.

Ex. II. *What is the 3d. power, or cube of* 38*?*

Now 38×38=1444 the 2d. power.
Then 1444×38=54872 the 3d. power.

51. The figure ſhewing the name of any power, is called the index of that power.

Thus 1 is the index of the 1ſt. power; 2 is the index of the 2d. power; 3 of the 3d. power, *&c.*

52. Any number may be conſidered as a power of ſome other number. Thus 64 may be taken as the 2d. power of 8, and the 3d. power of 4, *&c.*

53. The root of a given number conſidered as a power, is a number which being raiſed to the index of that power, will either be equal to the given number, or approach very near to it.

54 *To extract the Square Root of a given number.*

1ſt. Begin at the unit's place, put a point over it, and alſo over every next figure but one, reckoning to the left for integers, and to the right for fractions; and there will be as many integer places in the root, as there are points over the integers in the given number.

The figure under a point, with its left hand place, is called a period.

2d. Under the left hand period write the greateſt ſquare contained in it, and ſet the root thereof in the Quotient; ſubtract the ſquare, and to the remainder bring down the next period, as in Diviſion.

3d. On the left of this Remainder write the double of the Root or Quotient for a Diviſor; ſeek how often this may be had in the Remainder, except the right hand place; write what ariſes both in the Root, and on the right of the Diviſor.

4th. Multiply this increaſed Diviſor by the laſt Quotient figure; ſubtract, and to the Remainder bring down the next period; double the Root for a Diviſor, and proceed as before.

55. Fractional places will ariſe in the Root by annexing to the Remainders, periods of two cyphers each, and renewing the operation.

Ex. I. *What is the Square Root of* 1444?

Put a point over the units place 4, and alſo over the place of 100s. Now the number conſiſts of 2 periods, and will have 2 integer places in the Root: Then the greateſt Square in 14, the left hand period, is 9, and its Root is 3; write 9 under the period, and 3 in the Root; now 9 from 14 leaves 5, to which annex the next period 44; the Root 3 doubled makes 6, which in 54 is contained 8 times, annex 8 to the 3 and to the 6, makes the Root 38 and the Diviſor 68; then 8 times 68 is 544; and there remaining 0 on ſubtraction, it may be concluded that 38 is the true Root.

$1\dot{4}4\dot{4}$ (38 Root.
9

68) 544
544

Ex. II. *What is the Square Root of* 36372961?

$3\dot{6}3\dot{7}2\dot{9}6\dot{1}$ (6031 Root.
36

1203) 3729
3609

12061) 12061
12061

Ex. III. *What is the Square Root of* 1,0609?

$\dot{1},0\dot{6}0\dot{9}$ (1,03 Root.
1

203) 0609
609

Ex. IV. *What is the Square Root of* 24681024?
Anſwer 4968.

Ex. V. *What is the Square Root of* 911236798,794365?
Anſwer 30186,699.

Ex. VI. *What is the Square Root of* 76395820?

$7\dot{6}3\dot{9}5\dot{8}2\dot{0}$ (8740,4702
64

167) 1239
1169

1744) 7058
6976

174804) 822000
699216

1748087) 12278400
12236609

174809402) 417910000
349618804

68291196

In the 6th example, after all the periods given were brought down, there remained 8220, to which a period of two cyphers was annexed, and the operation renewed, and continued until 4 decimal places were obtained in the Root; every period brought down giving one place.

56 *To extract the Cube Root of a given number.*

Rule, 1ſt. Over the unit place of the given number put a point, and alſo over every third figure from the unit place, to the left for integers, and to the right for fractions; and the Root will have as many integer places, as there are points, or periods, in the integral part of the given number.

2d. Under the left hand period, write the greateſt Cube it contains, whoſe Root ſet in the Quotient: Subtract the Cube from the period, and to the Remainder annex the remaining periods; call this the Reſolvend.

3d. To the Quotient annex as many cyphers as there were periods remaining; call this the Root.

4th. Divide the Reſolvend by the Root, add the Quotient to thrice the Square of the Root, let the ſum be a Diviſor to the Reſolvend, and the Quotient figures annexed to the right of the firſt Root, without the cyphers, will be the Cube Root ſought.

5th. If the ſecond figure of the Root be 1, or 0; then generally 3 or 4 figures of the Root will be obtained at the firſt operation: But if the ſecond figure exceeds 2, it will be beſt to find only two places at firſt.

6th. To renew the operation; ſubtract the Cube of the figures found in the Root, from the given number; then form a Diviſor and divide as directed in the 4th precept; and this will give the Root true to 5 or 6 places: For each operation commonly triples the figures found in the laſt Root.

Ex. I. *What is the Cube Root of* 9800344?

Put a point over the unit place 4, another over the place of thouſands, and another over that of millions; and becauſe there are 3 points, there will be 3 places in the Root. Under the left hand period 9, write 8 the greateſt Cube therein, and its Root 2, write in the Quotient, then ſubtracting, the Reſolvend is 1800344: Now becauſe there are two periods remaining, therefore two cyphers annexed to the Root 2, makes it 200, by which dividing the Reſolvend, the Quotient is 9001; alſo the ſquare of 200 is 40000, the triple thereof 120000 being added to 9001, makes 129001 for a Diviſor, by which dividing 1800344, the Quotient is 14 nearly, and is taken as 14 becauſe it is much nearer to it than to 13; now 14 being annexed to the former Root 2, makes 214 the Root ſought.
For 214×214×214=9800344.

$\dot{9}80\dot{0}34\dot{4}$ (2
8

2,00)18003,44 Reſolvend.

9001 = Quotient.
120000 = thrice the Sq. of the R.

129001) 1800344 (14
129001

510334
516004

The Root is 214

Ex. II. *What is the Cube Root of* 518749442875?

518749442875 (8
512

8,000) 6749442,875
843680
192000000

192843680) 6749442875 (035
578531040
964132475
964218400

In this example, becauſe 3 periods were remaining, and conſequently 3 places more to be found; therefore in the laſt diviſion a point is put over the 3d. place from the right hand, and the Diviſor is firſt to be tried in the Dividend as far as this point, in which as it cannot be taken, 0 is put in the Quotient, &c. here the laſt figure 5 is too much, but it is much nearer to 5 than to 4; then 035 annexed to the firſt Root 8, makes 8035 for the Root.

Ex. III. *What is the Cube Root of* 114604290,028?

114604290,028 (4
64

4,00) 50604290
126510
480000
606510) 50604290 (8

Here 480 is taken for the Root at the firſt operation.

48
48
384
192
2304
48
18432
9216
110592

Then 114604290,028 (48
110592

480) 4012290

8358,9 the Quotient.
691200 = triple the Square of 480.

Diviſor 699558,9) 4012290,028 (5736
34977945

5144955
4896912

248043
209867

38176

To 480 the firſt Root
Add 5,736
Sum 485,736

57. Here inſtead of bringing down the figures of the Dividend to the Remainders, the Diviſor is leſſened each time by pointing off a place on the right; but regard is to be had to the carriage which will ariſe from the places thus omitted.

SECTION VIII. OF NUMERAL SERIES.

58. *A rank of three or more numbers that increaſe or decreaſe by an uniform progreſſion, is called a Numeral Series.*

59. If the Progreſſion is made by equal differences, that is by the conſtant addition or ſubtraction of the ſame number; the ſeries is called an *Arithmetic Progreſſion.*

Thus
1 2 3 4 5 6 7 8 9 &c. increaſing by adding 1.
3 6 9 12 15 18 21 24 27 &c. increaſing by adding 3.
49 43 37 31 25 19 13 7 1 &c. decreaſing by ſubducting 6.

are ranks of numbers in Arithmetic Progreſſion; and of ſuch ranks there may be an infinite variety.

60. If the Progreſſion is made by a conſtant multiplication or diviſion with the ſame number, the ſeries is called a *Geometric Progreſſion.*

Thus
1 2 4 8 16 32 64 &c. increaſing by 2
1 5 25 125 625 3125 15625 &c. increaſing by 5
6561 2187 729 243 81 27 9 3 &c. decreaſing by 3
16384 4096 1024 256 64 16 4 1 &c. decreaſing by 4

are ranks of numbers in Geometric Progreſſion; and of ſuch ranks there may be an infinite variety.

61. The common Multiplier or Diviſor is called the *ratio.*

Thus 2 is the ratio in the 1ſt. rank, 5 in the 2d. rank, 3 is the ratio in the 3d. rank, and 4 in the 4th. rank.

62. In any ſeries of terms in Arithmetic Progreſſion, the ſum of any two terms, conſidered as extremes, is equal to the ſum of any two terms taken as means equally diſtant from the extremes.

Thus in 3 terms (where the 1ſt. and 3d. are extremes, and the other the mean) *viz.* 6 . 9 . 12; then $6+12=9+9=18$.
And in 4 terms, *viz.* 13 . 19 . 25 . 31.
Then $13+31=19+25=44$.
Alſo in the terms 49 . 43 . 37 . 31 . 25 . 19 . 13 . 7 . 1.
Then $49+1=43+7=37+13=31+19=25+25=50$.

63. In a ſeries of terms in Geometric Progreſſion, the Product of any two terms conſidered as extremes, is equal to the Product of any two intermediate equidiſtant terms conſidered as means.

Thus in 3 terms, *viz.* 5 . 25 . 125. Or 3 . 9 . 27.
Then $5\times125=25\times25=625$. Alſo $3\times27=9\times9=81$.
And in 4 terms 4 . 8 . 16 . 32.
Then $32\times4=16\times8=128$.
Alſo in the terms 1 . 4 . 16 . 64 . 256 . 1024 . 4096 . 16384.
Then $16384\times1=4096\times4=1024\times16=256\times64=16384$.

64. **Problem I.** *In an Arithmetic Progreſſion: Given the firſt term, the common difference, and the number of terms.*
Required the laſt term.

Rule. Multiply the number of terms leſs one by the common difference, to the Product add the firſt term, and the ſum will be the laſt term.

Ex. I. *Suppoſe* 1 *and* 9 *to be the firſt and ſecond terms of an Arithmetic Progreſſion of* 1074 *terms: What is the laſt term?*

Here $9-1=8$ is the com. diff. Now $1074-1=1073$.
And $1073\times8=8584$. Then $8584+1=8585=$ laſt term.

Ex. II. *A perſon agrees to diſcharge a certain debt in a year, by weekly payments,* viz. *the firſt week* 5 *s. the* 2*d. week* 8 *s.* &c. *conſtantly increaſing each week by* 3 *s: How much was the laſt payment?*

5= 1ſt. term   Now $52-1=51$
3= com. diff.   And $51\times3=153$
52= N°. of terms. Then $153+5=158$ *s.* $=7$ £. 18 *s.* = laſt payment.

65. **Problem II.** *In an Arithmetic Progreſſion: Given the firſt term, laſt term, and the number of terms.*
Required the ſum of all the terms.

Rule. Add the firſt and laſt terms together, the ſum multiplied by half the number of terms, gives the ſum of all the terms.

Ex. I. *Required the ſum of the firſt* 1000 *numbers in their natural order.*

Here 1= 1ſt. term, 1= com. diff.
1000=N°. of terms, its $\frac{1}{2}$ is 500.
Now $1000+1=1001$.
Then $1001\times500=500500$ is the ſum required.

Ex. II. *A debt is to be diſcharged in a year by weekly payments equally increaſing; the* 1*ſt. to be* 5 *s. and the laſt* 7 £. 18 *s: How much was the debt?*

Here 7 £. 18 *s.* = 158 *s.* = laſt term.
52=N°. of terms, its $\frac{1}{2}$ is 26.
Now $158+5=163$.
Then $163\times26=4238$ *s.* = 211 £. 18 *s.* is the ſum of the terms, or debt.

Ex. III. *Suppoſe a baſket and* 500 *ſtones were placed in a ſtrait line a yard diſtant from one another: Required in what time a man could bring them one by one to the baſket, allowing him to walk at the rate of* 3 *miles an hour?*

Between the baſket and ſtones are 500 ſpaces, which is the N°. of terms.
Now $500+1=501$. Then $501\times250=125250=$ ſum of the terms,
But as he goes backwards and forwards, he walks 250500 yards.
Which divided by 1760 (the yards in 1 mile) gives 142,329 miles.
Which at 3 miles an hour, will take 47 h. 26 min. 34 ſeconds.

66. **Problem III.** *In a Geometric Progreſſion: Given the firſt term, the ratio and the laſt term.*

Required the ſum of all the terms.

Rule. Multiply the laſt term by the common ratio, from the Product ſubtract the firſt term for a Dividend.

Subtract 1 from the ratio for a Diviſor; then divide, and the Quotient will be the ſum of all the terms.

Ex. I. *Suppoſe the firſt term of a ſeries to be 3, the ratio 3, and the laſt term 6561: Required the ſum of all the terms.*

Now 6561 = laſt term And 3 = ratio
Mult. by 3 = ratio Subt. 1

19683 = Product Rem. 2 = Diviſor.
Subtr. 3 = firſt term

19680 = Dividend

Then 2) 19680 (9840 is the ſum of all the terms.

Ex. II. *Let the firſt term be 2, the ſecond term 10, and the laſt term 156250: Required the ſum of all the terms.*

Here 2) 10 (5 is the common ratio.
Now 156250×5=781250. And 781250—2=781248= Dividend.
Alſo 5—1=4 the Diviſor.
Then 4) 781248 (195312 is the ſum of all the terms.

67. **Problem IV.** *In a Geometric Progreſſion: Given the firſt term, the ratio, and the number of terms.*

Required the laſt term.

Rule. Raiſe the common ratio to a power leſs 1 than the number of terms; multiply this power by the firſt term, and the Product will be the laſt term.

Ex. I. *What is the 10th term of a Geometric Series whoſe firſt term is 2, and the ſecond term is 6?*

Here 2) 6 (3 is the common ratio.
Then 3×3=9=2d. power.
9×3=27=3d.
27×3=81=4th.
81×3=243=5th.
243×3=729=6th.
729×3=2187=7th.
2187×3=6561=8th.
6561×3=19683=9th.
19683×2=39366=10th. term.

Ex. II. *What is the 12th term of a Geometric Series whoſe firſt term is 3, and 2d. term is 6?*

Here 3) 6 (2 is the com. ratio.
Then 2 raiſed to the 11th power as in Ex. I. will be 2048, which multiplied by 3 the 1ſt. term gives 6144 for the 12th. term ſought.

As this method is extremely tedious when a diſtant term from the firſt is required; therefore the following method is moſt convenient for ſuch operations.

68. In any Arithmetic Progreſſion, the ſum of any two terms leſſened by the firſt term, or their difference increaſed by the firſt term, will be alſo a term in that progreſſion.

Thus in the Progreſſion 1. 3. 5. 7. 9. 11. 13. 15. 17. 19. 21 &c.
Then $7+11=18$, and $18-1=17$ is a term of the Progreſſion.
Alſo $11-7=4$, and $4+1=5$ is a term of the Progreſſion.
And the like of the ſum or difference of any other two terms.

69. In any Geometric Progreſſion, the product of any two terms divided by the firſt term; or the Quotient of any two terms multiplied by the firſt term, will give a term alſo in that ſeries.

Thus in the progreſſion 3. 6. 12. 24. 48. 96. 192, 384, 768, &c.

Then $\frac{12\times96}{3}=384$; and $\frac{192}{12}\times3=48$, are terms in the Progreſſion.

70. If over a ſeries of terms in Geometric Progreſſion, be wrote a ſeries of terms in Arithmetic Progreſſion, whoſe firſt term is 0, and com. diff. is 1, term for term; then any term in the Arithmetic Series, will ſhew how far its correſponding term in the Geometric Series, is diſtant from the firſt term.

Thus	0	1	2	3	4	5	6	&c.	Arithmetic Series.
	1	3	9	27	81	243	729	&c.	Geometric Series.

Here 729 is diſtant from the 1ſt. term, 6 terms; 243 is diſtant 5 terms; 81 is diſtant 4 terms &c.

71. The terms of the Arithmetical Series are called Indices to the terms of the Geometrical Series.

And hence ariſes the following ready method of finding any diſtant term in a propoſed Geometric Progreſſion.

72. Rule, 1ſt. Write down 6 or 7 of the leading terms in the Geometric Series, and over them their Indices.

2d. Add together the moſt convenient Indices to make an Index leſs by one than the number expreſſing the place of the term ſought.

3d. Multiply together the terms of the Geometric Series, belonging to thoſe Indices which were added, make the product a Dividend.

4th. Raiſe the firſt term to a power whoſe Index is the number of terms multiplied leſs one; make the reſult a Diviſor to the former Dividend, and the Quotient will be the term ſought.

When the firſt term is Unity, the foreſaid Dividend is the term ſought.

Ex. *What is the 20th term in the Geometric Series* 1 . 3 . 9 . 27 . &c.?

Here	0	1	2	3	4	5	6	&c.	Indices.
	1	3	9	27	81	243	729	&c.	Geom. terms.

And as 20 is the number of the place of the term ſought; therefore ſuch Indices are to be added together, as will moſt readily make 19.
Then $6+6=12$; $12+6=18$; and $18+1=19$ is the Index to the 20th term.
Now the Geom. term belonging to the Index 6, is 729.
And as the ſum of 6 and 6 made the Index 12.
So $729\times729=531441$ is the Geom. term to the Index 12.
And as the ſum of 6 and 12 made the Index 18.
So $531441\times729=387420489$ is the Geom. term to the Index 18.
And as the ſum of 18 and 1 made the Index 19.
So 387420489×3 (belonging to the Index 1)$=1162261467$ is the Geom. term to the Index 19, or the 20th term in the propoſed ſeries.

SECTION IX. OF LOGARITHMS.

73. LOGARITHMS *are a ſeries of numbers ſo contrived, that by them the work of multiplication may be performed by addition*; *and that of diviſion may be done by ſubtraction.*

Theſe Logarithms are the Indices to a ſeries of numbers in Geometrical Progreſſion.

Thus	0	1	2	3	4	5	6	&c. Indices or Logarithms.
	1	2	4	8	16	32	64	&c. Geometric Progreſſion.
	0	1	2	3	4	5		&c. Indices or Logarithms.
or	2	6	18	54	162	486		&c. Geometric Series.
	0	1	2	3	4	5		&c. Indices or Logarithms.
or	1	10	100	1000	10000	100000		&c. Geom. Series.

Theſe Indices ſerve equally for any Geometric Series.

74. Hence it is evident there may be as many kinds of Indices or Logarithms, as there can be taken kinds of Geometric Series.

75. But the Logarithms moſt convenient for common uſes, are thoſe adapted to a Geometric Series increaſing in a tenfold Progreſſion, as in the laſt of the examples above.

Now in this Geometric Series, between the terms 1 and 10, if the numbers 2 . 3 . 4 . 5 . 6 . 7 . 8 . 9 were interpoſed, to them might Indices be alſo adapted in an Arithmetic Progreſſion, ſuited to the terms interpoſed between 1 and 10, conſidered as a Geometric Progreſſion: Alſo proper Indices may be found to all the numbers that can be interpoſed between any two terms of the Geometric Series.

But it is evident that all the Indices to the numbers under 10 muſt be leſs than 1; that is, are fractions: Thoſe to the numbers between 10 and 100 muſt fall between 1 and 2; that is, are mixed numbers conſiſting of 1 and ſome fraction: And ſo the Indices to the numbers between 100 and 1000 will fall between 2 and 3; that is, are mixed numbers conſiſting of 2 and ſome fraction: And ſo of the other Indices.

76. Hereafter the integral part only of theſe Indices, will be called the Index; and the fractional part will be called the Logarithm: And the computing of theſe fractional parts is called the making of Logarithms; the moſt troubleſome part of this work is to make the Logarithms of the *prime numbers*; that is, of ſuch numbers which cannot be divided by any other number than by itſelf and unity.

77. *To find the Logarithms of prime numbers.*

Rule, 1ſt. Let the ſum of the propoſed number and its next leſſer number be called A.

2d. Divide 0,868588963 by A, reſerve the Quotient.

3d. Divide the reſerved Quotient by the Square of A, reſerve this Quotient.

4th. Divide the laſt reſerved Quotient by the Square of A, reſerving the Quotient; and thus proceed as long as diviſion can be made.

5th. Write the reſerved Quotients orderly under one another, the firſt being uppermoſt.

6th. Divide theſe Quotients reſpectively by the odd numbers 1 . 3 . 5 . 7 . 9 . 11, &c. that is, divide the firſt reſerved Quotient by 1, the 2d. by 3, the 3d. by 5, the 4th. by 7, &c. let theſe Quotients be wrote orderly under one another, add them together, and their ſum will be a Logarithm.

7th. To this Logarithm, add the Logarithm of the next leſſer number, and the ſum will be the Logarithm of the number propoſed.

Ex. I. *Required the Logarithm of the number* 2.

Here the next leſs number is 1. And $2+1=3=A$.
And the Square of A is 9. Then

$$\frac{0,868588963}{3}=,289529654 \quad \text{And} \quad \frac{,289529654}{1}=,289529654$$

$$\frac{0,289529654}{9}=,032169962 \quad \& \quad \frac{,032169962}{3}=,010723321$$

$$\frac{0,032169962}{9}=,003574440 \quad \& \quad \frac{,003574440}{5}=,000714888$$

$$\frac{0,003574440}{9}=,000397160 \quad \& \quad \frac{,000397160}{7}=,000056737$$

$$\frac{0,000397160}{9}=,000044129 \quad \& \quad \frac{,000044129}{9}=,000004903$$

$$\frac{0,000044129}{9}=,000004903 \quad \& \quad \frac{,000004903}{11}=,000000445$$

$$\frac{0,000004903}{9}=,000000545 \quad \& \quad \frac{,000000545}{13}=,000000042$$

$$\frac{0,000000545}{9}=,000000060 \quad \& \quad \frac{,000000060}{15}=,000000004$$

To this Log. 0,301029994
Add the Log. of 1=0,000000000

Their ſum is the Log. of 2=0,301029994

This proceſs needs no other explanation than comparing it with the rule.

78. The number 0,868588963 is the Quotient of 2 divided by 2,302585093, which is the Logarithm of 10, according to the firſt form of the Lord *Nepier*, who was the inventor of Logarithms. The manner whereby *Nepier*'s Log. of 10 is found, may be ſeen in many books of

Algebra; but is here omitted, becauſe this treatiſe does not contain the elements of that ſcience: However thoſe who have not opportunity to enter thoroughly into this ſubject, had better grant the truth of one number, and thereby be enabled to try the accuracy of any Logarithm in the tables, than to receive thoſe tables as truly computed, without any means of examining the certainty thereof.

That the manner of computing theſe Logarithms may be familiar to the reader, the operations of making ſeveral of them are here ſubjoined.

Ex. II. *Required the Logarithm of the number* 3.

Here the next leſs number is 2; and 3+2=5=A, whoſe Square is 25.

$$\begin{array}{llll}
\frac{0,868588963}{5}=,173717792. & \text{And} & \frac{,173717792}{1}= & ,173717792 \\
\frac{0,173717792}{25}= \; 6948712. & \& & \frac{6948712}{3}= & 2316237 \\
\frac{0.006948712}{25}= \; 277948. & \& & \frac{277948}{5}= & 55590 \\
\frac{0,000277948}{25}= \; 11118. & \& & \frac{11118}{7}= & 1588 \\
\frac{0.000011118}{25}= \; 445. & \& & \frac{445}{9}= & 49 \\
\frac{0,000000445}{25}= \; 18. & \& & \frac{18}{11}= & 2
\end{array}$$

To this Logarithm	0,176091258
Add the Log. of 2.	0,301029992
The ſum is the Logarithm of 3	0,477121250

Since the Logarithms are the Indices of numbers conſidered in a Geometric Progreſſion; therefore the ſums, or differences, of theſe Indices, will be Indices or Logarithms belonging to the Products, or Quotients, of ſuch terms in the Geometric Progreſſion as correſpond to thoſe Logarithms as were added or ſubtracted. (72).

Ex. III. *Required the Log. of* 4.

Now 4=2×2.

Then to the Log. of 2	0,301029992
Add the Log. of 2	0,301029992
Sum is the Log. of 4	0,602059984

Ex. V. *Required the Log. of* 10.

In the original Series, 1 is aſſumed for the Logarithm of 10.

Ex. VII. *Required the Log. of* 8.

Now 8=2×2×2.

Therefore the Log. of 2 taken thrice gives the Log. of the number 8.

The Log. of 2 is	0,301029992
Which multiplied by	3
Gives the Log. of 8.	0.903089976

Ex. IV. *Required the Log. of* 6.

Now 3×2=6.

Then to the Log. of 3	0,477121250
Add the Log. of 2	0,301029992
Sum is the Log. of 6	0,778151242

Ex. VI. *Required the Log. of* 5.

Now 10 divided by 2 gives 5.

Then from Log. of 10	1,000000000
Take Log. of 2	0.301029992
Leaves the Log. of 5	0.698970008

Ex. VIII. *Required the Log. of* 9.

Now 9=3×3.

Therefore the Log. of 3 doubled gives the Log. of 9.

The Log. of 3 is	0,477121250
Which multiplied by	2
Gives the Log. of 9.	0.954242500

Ex. IX. *Required the Logarithm of* 7.

Here 6 is the next leſſer. Then $7+6=13=A$; and $169=$ Square of A,

$$\frac{0,868588963}{13}=,066814536. \quad \text{And} \quad \frac{,066814536}{1}=,066814536$$

$$\frac{0,066814536}{169}=395352. \quad \& \quad \frac{395352}{3}=131784$$

$$\frac{0,000395352}{169}=2339. \quad \& \quad \frac{2339}{5}=468$$

$$\frac{0,000002330}{169}=14. \quad \& \quad \frac{14}{7}=2$$

To this Logarithm	0,066946790
Add the Logarithm of 6	0,778151242
The ſum is the Logarithm of 7	0,845098032

The Log. of 12 is equal to the ſum of the Logs. of 3 & 4, or of 2 & 6.
The Log. of 14 is equal to the ſum of the Logs. of 7 & 2
of 15 of 3 & 5
of 16 of 4 & 4, or of 8 & 2
of 18 of 3 & 6, or of 9 & 2
of 20 of 4 & 5, or of 10 & 2

79. The Logs. of the prime numbers 11, 13, 17, 19, are to be found as in the examples I. II. IX. and in like manner is the Log. of any other prime number to be found; but it may be obſerved, that the operation is ſhorter in the larger prime numbers; for any number exceeding 400, the firſt Quotient added to the Logarithm of its next leſſer number, will give the Logarithm ſought, true to 8 or 9 places; and therefore it will be very eaſy to examine any ſuſpected Logarithm in the tables.

80. The manner of diſpoſing the Logarithms when made, into tables is various: But in this treatiſe they are ordered as follows.

Any number under 100, *or not exceeding two places, and its Logarithm, is found in the firſt page of the table,* where they are placed in adjoining columns; and diſtinguiſhed by the title *Num.* for the common numbers; and by *Log.* for the Logarithms.

A number of three or four places being given, its Logarithm is thus found.

Seek for a page in which the given number ſhall be contained between the two numbers marked at the top, annexed to the letter N: Then right againſt the three firſt figures of the given number, found in the column ſigned *Num*, and in the column ſigned by the fourth, ſtands the Logarithm belonging to that number of four places.

If the number conſiſted of 3 places only; then theſe places found as before directed, the Logarithm ſtands againſt them in the column ſigned o.

Thus, *to find the Logarithm of* 5738. Seek for a page wherein ſtands at top N. 5500 to 6000; then in the column ſigned Num. find 573, right againſt which in the column ſigned 8, ſtands ,75876 which is the Logarithm to 5738, excluſive of its Index.

81. *A Logarithm being given, its number is thus found.*

Seek for a page wherein the three firſt figures of the given Logarithm is found at top annexed to the letter *L*; then in one of the columns ſigned with the figures 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, find a number the neareſt to the given Logarithm; againſt this number in the column ſigned Num. ſtand three figures, to the right of theſe annex the figure with which the column was ſigned, and this will be the number correſponding to the given Logarithm, not regarding the Index.

82. A general rule to find the Index to the Log. of a given number.

To the left of the Logarithm, write that figure (or figures) which expreſſes the diſtance from unity, of the higheſt-place digit in the given number, reckoning the unit's place 0, *the next place* 1, *the next place* 2, *the next place* 3, &c.

When there are integers in the given number, the Index is always affirmative; but when there are no integers, the Index is negative, and is to be marked by a little line drawn above it: thus $\overline{2}$.

Thus a number having 1 . 2 . 3 . 4 . 5 *&c.* integer places.

The Index of its Logarithm is 0 . 1 . 2 . 3 . 4 *&c.*

And a fraction having a digit in the place of Primes. Seconds. Thirds. Fourths *&c.*

Then the Index of its Logarithm will be $\overline{1}$. $\overline{2}$. $\overline{3}$. $\overline{4}$ *&c.*

By the above rule, the place of the fractional comma, or mark of diſtinction, in the number anſwering to a given Logarithm, will be always known.

83. The more places the Logarithms conſiſt of, the more accurate, in general, will be the reſult of any operation performed with them: But for the purpoſes of Navigation, as five places, excluſive of the Index, are ſufficient, therefore the logarithmic tables in this treatiſe are not extended any farther.

84. All numbers conſiſting of the ſame figures, whether they be integral, fractional, or mixed, have the fractional parts of their Logarithms the ſame.

If the following examples be well attended to, there will be no difficulty in finding the Logarithm to a propoſed number, or the number to a propoſed Logarithm, within the limits of the table of Logarithms here uſed.

Num.	Logarithms	Logarithms	Numbers.
5874	3,76893	0,37295	2,360
587,4	2,76893	1,28631	19,33
58,74	1,76893	2,51947	330,7
5,874	0,76893	3.75062	5632,
0,5874	$\overline{1}$.76893	$\overline{3}$,18397	0,001527
0,05874	$\overline{2}$,76893	$\overline{2}$,43020	0,02693
0,005874	$\overline{3}$,76893	$\overline{1}$,85962	0,7238

85. MULTIPLICATION BY LOGARITHMS;

Or, Two or more numbers being given, to find their Product by Logarithms.

Rule. Add together the Logarithms of the Factors, and the ſum is a Logarithm, whoſe correſponding number is the Product required.

Obſerving to add what is carried from the Logarithm to the ſum of the affirmative Indices.

And that the difference between the affirmative and negative Indices are to be taken for the Index to the Logarithm of the Product.

Ex. I. *Multiply* 86,25 *by* 6,48.

86,25 its Log. is	1,93576
6,48 its Log. is	0,81157
Product 558,9	2,74733

Ex. III. *Multiply* 3,768 *by* 2,053 *and by* 0,007693.

3,768 its Log. is	0,57611
2,053	0,31239
0,007693	$\bar{3}$,88610
Product 0,05951	$\bar{2}$,77460

The 1 carried from the left hand column of the Logs. being affirmative, reduces $\bar{3}$ to $\bar{2}$.

Ex. II. *Multiply* 46,75 *by* 0,3275.

46,75 its Log. is	1,66978
0,3275 its Log. is	$\bar{1}$,51521
Product 15,31	1,18499

Ex. IV. *Multiply* 27,63 *by* 1,859 *and by* 0,7258 *and by* 0,03591.

27,63 its Log. is	1,44138
1,859	0,26928
0,7258	$\bar{1}$,86082
0,03591	$\bar{2}$,55521
Product 1,339	0,12669

Here 2 being carried to the Index 1, makes 3; which takes off the $\bar{1}$ and $\bar{2}$.

86. DIVISION BY LOGARITHMS;

Or, Two numbers being given, to find how often the one will contain the other, by Logarithms.

Rule. From the Log. of the Dividend, ſubtract the Log. of the Diviſor; then the number agreeing to the Remainder, will be the Quotient required.

But obſerve, to change the Index of the Diviſor from negative to affirmative, or from affirmative to negative: And then let the difference of the affirm. and neg. Indices be taken for the Index to the Log. of the Quotient.

When an unit is borrowed in the left hand place of the Logarithm, add it to the Index of the Diviſor, if affirmative; but ſubtract it if negative; and let the Index ariſing be changed and worked with as before.

Ex. I. *Divide* 558,9 *by* 6,48.

The Log. of the Div. 558,9 is	2,74733
The Log. of the Diviſor 6,48 is	0,81157
The Quotient is 86,25	1,93576

Ex. II. *Divide* 15,31 *by* 46,75.

The Log. of the Div. 15,31 is	1,18497
The Log. of the Diviſor 46,75 is	1,66978
The Quotient is 0,3275	$\bar{1}$,51519

Ex. III. *Divide* 0,05951 *its Log. is* $\bar{2}$,77459

Ex. III. *Divide* 0,05951 *its Log. is*	$\bar{2}$,77459
By 0,007693	$\bar{3}$,88610
The Quotient is 7,735	0,88849

87. OF PROPORTION.

1ſt. State the terms of the queſtion (by 46) and let them be wrote orderly under one another, prefixing to the firſt term the word *As*, to the ſecond *To*, to the third *So*, and under them ſet the word *To*.

2d. Againſt the firſt term, write the arithmetical complement of its Logarithm.

3d. Againſt the ſecond and third terms, write their Logarithms.

4th. The ſum of theſe three Logarithms, abating 10 in the Index, will be the Logarithm of the fourth term; which ſought in the tables, the number anſwering thereto, is the anſwer or term ſought.

88. The arithmetical complement of a Logarithm is thus found. Beginning at the Index, write down what each figure wants of 9, except the laſt, which take from 10.

But if the Index is negative, add it to 9; and proceed with the reſt as before.

Ex. I. *Find a fourth proportional number to* 98,45 *and* 1,969 *and* 347,2.

As	98,45	8,00678
To	1,969	0,29425
So	347,2	2,54058
To	6,914	0,84161

Ex. III. *What will a gunner's pay amount to in a year at* 2 £. 12 *s.* 6*d. a month of* 28 *days?*

As	28 days	8,55286
To	365 days	2,56229
So	2£. 12 *s.* 6 *d.*=2,625£.	0,41913
To	34£. 4 *s.* 5 *d.*=34,22£.	1,53428

Ex. V. *What number will have the ſame proportion to* 0,8538 *as* 0,3275 *has to* 0,0131?

As	0,0131	11.88273
To	0,3275	$\bar{1}$,51521
So	0,8538	$\bar{1}$,93125
To	21,34	1,32919

Ex. II. *Find a third proportional number to* 9,642 *and* 4,821.

As	9,642	9,01583
To	4,821	0,68314
So	4,821	0,68314
To	2,411	0,38211

Ex. IV. *If* $\frac{3}{4}$ *of a yard of cloth coſt* $\frac{2}{3}$ *of a guinea: How many ells Engliſh for* 3£. 10 *s?*

As	$\frac{2}{3}$ Guin. =14 *s.*	8,85387
To	3£. 10 *s.*=70 *s.*	1,84510
So	$\frac{3}{5}$ ell =0,6	1,77815
To	3 ells	0,47712

Ex. VI. *How many yards of ſhalloon of* $\frac{3}{4}$ *ell wide will be enough to line a coat containing* $3\frac{1}{2}$ *ells of* $1\frac{3}{4}$ *yards wide?*

As	$\frac{3}{4}\times\frac{5}{4}$ yd. w.=0,9375	10,02803
To	$1\frac{3}{4}$ yd. w =1,75	0,24304
So	$3\frac{1}{2}\times\frac{5}{4}$yd. l. =4,375	0,64098
To	$8\frac{1}{6}$ yd. long=8,167	0,91205

OF POWERS AND THEIR ROOTS.

90. *A number being given, to find any propoſed power thereof.*

Rule, 1ſt. Seek the Logarithm of the given number.

2d. Multiply this Logarithm by the Index of the propoſed power.

3d. Find the number correſponding to the Product, and it will be the power required.

Ex. I. *What is the 2d. power of the number* 3,874?

To 3,874 its Log. is 0,58816
The Index is 2
The power ſought is 15,01 1,17632

Ex. II. *What is the 3d. power of the number* 2,768?

The num. 2,768, its Log. is 0,44217
The Index is 3
The power ſought is 21,21 1,32651

Ex. III. *What is the 12th. power of the number* 1,539?

1,539 its Log. is 0,18724
The Index is 12
The power ſought is 176,6 2,24688

Ex. IV. *What is the 365th. power of the number* 2?

2 its Log. is 0,30103
The Index is 365
150515
180618
90309
109,87595

In the IV. Ex. the Index of the Product being 109, ſhews that the required power will conſiſt of 110 integer places; of which no more than 4 places are found in theſe tables; therefore the number ſought may be thus expreſſed 7515 [$\overline{106}$]: That is 7515 with 106 cyphers annexed.

91. *A number being given, to find any propoſed Root thereof.*

Rule. Divide the Logarithm of the given number or power, by the Index of the propoſed Root; and the number correſponding to the Quotient will be the Root required.

Ex. I. *What is the Square Root of the number* 1501?

2) 3,17638
Root ſought is 38,74 1,58819

Ex. II. *What is the Cube Root of the number* 2121?

3) 3,32654
Root ſought is 12,85 1,10885

Ex. III. *What is the Root, whereof* 176,6 *is the* 12th. *power?*

12) 2,24686
Root ſought is 1,539 0,18724

Ex. IV. *What is the Root, whereof* 2 *is the* 365th. *power?*

365) 0,30103
Root ſought is 1,002 0,00082

THE ELEMENTS OF NAVIGATION.

BOOK II.

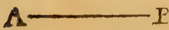
OF GEOMETRY.

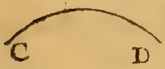
SECTION I.

Definitions and *Principles.*

92. GEOMETRY is a ſcience which treats of the deſcriptions, properties and relations of magnitudes in general: Or of ſuch things where length, or where length and breadth, or length breadth and thickneſs are conſidered.

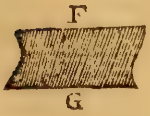
93. A Point is that which is without parts or dimenſions.





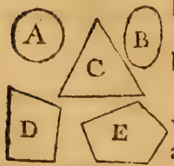
94. A Line is length without breadth: It is called a Right Line when 'tis the ſhorteſt diſtance between two points (as A B): Or a Curved Line when it is not the ſhorteſt diſtance (as C D).

A line is uſually denoted by two letters, viz. one at each end (as A B, C D).



95. A Superficies or Surface is that magnitude which has only length and breadth, and is bounded by lines, as F G.

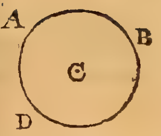
96. A Solid is that magnitude which has length breadth and thickneſs.



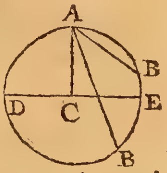
97. A Figure is a bounded ſpace, whoſe limits or bounds may be either lines or ſurfaces.

98. A Plane or a Plane figure is a ſuperficies which lies evenly, or perfectly flat, between its limits; and may be bounded by one curve line; but not with leſs than three right lines, as A, B, C, D or E, *&c.*

99. A



99. A **Circle** is a plain figure bounded by an uniformly curved line called the Circumference (as A B D), which is every where equally diſtant from one point (C) within the figure, called the **Centre**.



100. A **Radius** is a right line drawn from the centre to the circumference (as C A, C D, C E).

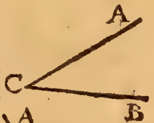
All the radii of the ſame circle are equal.

101. An **Arc** is any part of the circumference (as A B or A D).

102. A **Chord** is a right line joining the ends of an arc (as A B) and is ſaid to ſubtend that arc; it divides the circle into two parts called ſegments.

103. A **Diameter** is a chord paſſing thro' the centre (as D E), and divides the circle into two equal parts called **Semicircles**.

104. The **Circumference** of every circle is ſuppoſed to be divided into 360 equal parts called **Degrees**; each degree into 60 equal parts called **Minutes**; each minute into 60 equal parts called **Seconds**, *&c.*

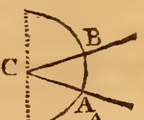


105. A **Plane Angle** is the aperture or inclination of two lines on the ſame plane, meeting in a point (as A C B).

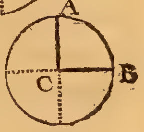
A right lined angle is formed by two right lines. The point where the lines meet is called the *angular point* (as C).

The lines which form the angle are called *legs* (as C A, C B).

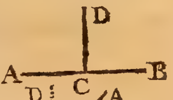
An angle is uſually marked by three letters, viz. one at the angular point, and one at the other end of each leg; but that at the angular point is always to be read the middle letter (as A C B, or B C A.



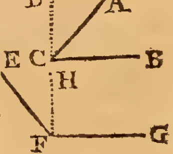
106. The meaſure of a right lined angle, is an arc (B A) contained between the legs (C B, C A) including the angle, the angular point (C) being the centre of that arc.



107. A **Right Angle** is that whoſe meaſure is a fourth part of the circumference of a circle, or ninety degrees. Thus the angle A C B is a right angle.



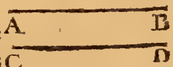
108. A **Perpendicular** is that right line which cuts another at right angles; or which makes equal angles on both ſides. Thus D C is perpendicular to A B, when the angles D C A and D C B are equal, or are right angles.



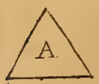
109. An **Acute Angle** (A C B) is that which is leſs than a right angle (D C B).

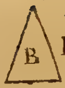
110. An **Obtuse Angle** (E F G) is that which is greater than a right angle (H F G).

Acute and obtuſe angles are called **Oblique Angles**.

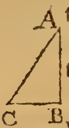


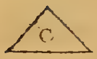
111. **Parallel Lines**, are ſuch right lines in the ſame plane, which do not incline to one another (as A B, C D).





112. A TRIANGLE is a plane figure bounded by three lines.

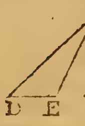


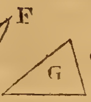


113. An EQUILATERAL TRIANGLE is that whoſe three lines or ſides are equal (as A).

114. An ISOSCELES TRIANGLE is that which has only two equal ſides (as B or C).

115. A RIGHT ANGLED TRIANGLE (A B C) is that which has one right angle (B).



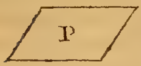


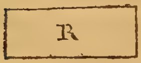
116. An OBTUSE ANGLED TRIANGLE (D E F), has one obtuſe angle (E).

117. An ACUTE ANGLED TRIANGLE (G) has all its angles acute.

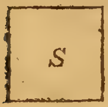
118. A QUADRANGLE is a plane figure bounded by four right lines or ſides.

A Quadrangle is uſually expreſſed by letters at the oppoſite angles.



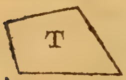


119. A PARALLELOGRAM is a quadrangle whoſe oppoſite ſides are parallel and equal (as P).

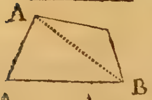


120. A RECTANGLE is a parallelogram with right angles; and whoſe length is greater than its breadth (as R).

121. A SQUARE is a parallelogram having four equal ſides, and right angles (as S).

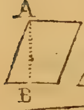


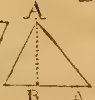
122. A TRAPEZIUM is a quadrangle whoſe oppoſite ſides are not parallel (as T).

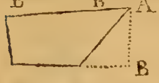


123. The DIAGONAL of a quadrangle, is a line (AB) drawn from one angle, to its oppoſite angle.

124. The BASE of a figure, is the line it is ſuppoſed to ſtand on.

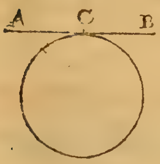




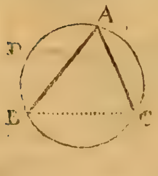


125. The ALTITUDE or HEIGHT of a figure, is the perpendicular diſtance (AB) between the baſe, and the vertex or part moſt remote from the baſe.

126. CONGRUOUS FIGURES, are thoſe which agree, or correſpond, with one another, in every reſpect.



127. A TANGENT to a circle is a right line (AB) touching its circumference but not cutting; and the point (C) where it touches, is called the point of contact.



128. An ANGLE (B A C) *in a Segment* (C A D B) is, when the angular point is in the circumference of the ſegment, and the legs including the angle paſs thro' the ends (B, C) of the chord of the ſegment.

Such an angle is ſaid to be in a circumference; and to ſtand on the arc (B C) *included between the legs* (A B, A C) *of the angle.*

129. Right lined figures having more than four ſides, are called *Polygons*; and have their names from the number of their angles or ſides; as thoſe of five ſides are called Pentagons; of ſix ſides Hexagons; of ſeven ſides Heptagons; of eight ſides Octogons, *&c.*

130. A Regular Polygon is a figure with equal ſides, and equal angles.

131. A figure is ſaid to be inſcribed in a circle, when all the angles of that figure are in the circumference of the circle.

132. A figure is ſaid to circumſcribe a circle, when every ſide is touched by the circumference of the circle.

133. A Propoſition is ſomething propoſed to be conſidered; and requires either a ſolution or anſwer, or that ſomething be made out or proved.

A Problem is a practical propoſition, in which ſomething is propoſed to be done, or effected.

A Theorem is a ſpeculative propoſition, or rule, in which ſomething is affirmed to be true.

A Corollary is ſome concluſion gained from a preceding propoſition.

A Scholium is a remark on ſome propoſition; or an exemplification of the matter which it contains.

An Axiom is a ſelf evident truth, or principle, that every one aſſents to upon hearing it propoſed.

A Poſtulate is a principle, or condition, requeſted; the ſimplicity or reaſonableneſs of which cannot be denied.

In Mathematics, the following Poſtulates and Axioms, are ſome of the principles that are generally taken for granted.

POSTULATES.

134. I. That a right line may be drawn from any given point to another given point.

135. II. That a given right line may be continued, or lengthened, at pleaſure.

136. III. That from a given point, and with any radius, a circle may be deſcribed.

AXIOMS.

137. I. Things equal to the ſame thing, are equal to one another.

138. II. If equal things are added to equal things, the ſums or wholes will be equal. But if unequals be added, the ſums are unequal.

139. III. If equal things are taken from equal things, the remainders or differences are equal: But are unequal, when unequals are taken.

140. IV. Things are equal, which are double, triple, quadruple *&c.* or half, third part *&c.* of one and the ſame thing, or of equal things.

141. V. Things which have equal meaſures, are equal.

142. VI. Equal circles have equal radii.

143. VII. Equal arcs in equal circles have equal chords, and are the meaſures of equal angles, and the contrary.

144. VIII. Parallel right lines, have each the ſame inclination to a right line cutting them.

In what follows. When a circle or arc is ſaid to be deſcribed from a letter, it is to be underſtood as deſcribed from the point which that letter denotes, or marks out as a centre. And the like is to be underſtood of the points where lines or arcs cut one another.

145. It is alſo taken for granted, that a line or diſtance can be taken between the compaſſes and may be transferred or applied from one place to another.

SECTION II.

Geometrical Problems.

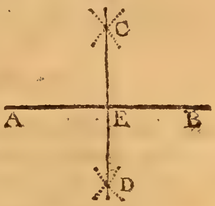
146. PROBLEM I.

To biſect, or divide into two equal parts, a given line A B.

Operation, 1ſt. From the ends A and B, with one and the ſame radius, greater than half A B, deſcribe arcs cutting in C and D.

2d. A ruler laid by C and D, gives E, the middle of A B, as required.

The proof of this operation depends on articles 191, 189.



147. PROBLEM II.

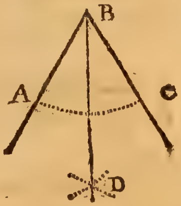
To biſect a given right lined angle A B C.

Operation, 1ſt. From B, deſcribe an arc AC.

2d. From A and C, with one and the ſame radius deſcribe arcs cutting in D.

3d. A right line drawn thro' B and D will divide the angle into two equal parts as required.

The proof depends on art. 191.



148. PROBLEM III.

From a given point B, *in a given right line* A F, *to draw a right line perpendicular to the given line.*

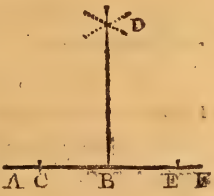
When B is near the middle of the line

Operation, 1ſt. On each ſide of B, take the equal diſtances B C, and B E.

2d. On C and E deſcribe, with one radius, arcs cutting in D.

3d. A right line drawn thro' B and D will be the perpendicular required.

The proof depends on art. 193.



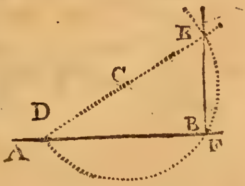
149. *When* B *is at, or near the end of the given line.*

Operation, 1ſt. On any convenient point C, taken at pleaſure, with the diſtance or radius C B deſcribe an arc D B E, cutting AF in D, B.

2d. A ruler laid by D and C will cut this arc in E.

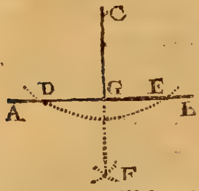
3d. A right line drawn thro' B and E will be the perpendicular required.

This depends on art. 213.



150. PROBLEM IV.

To draw a line perpendicular to a given right line AB, *from a point* C *without that line.*



When the point C is nearly oppoſite to the middle of the given line.

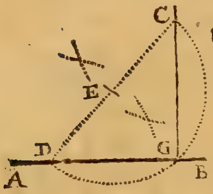
OPERATION, 1ſt. On C with one radius cut AB in D and E.

2d. On D and E with one radius deſcribe arcs cutting in F.

A ruler laid by C and F gives G; then draw C G and that will be the perpendicular required.

This depends on art. 191, 189.

151. *When* C *is nearly oppoſite to one end of the given line* A B.



OPERATION, 1ſt. To any point D in A B, draw the line C D.

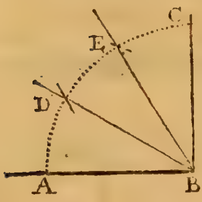
2d. Biſect the line C D in E. (146).

3d. On E with the radius E C, cut A B in G. Then C G being drawn will be the perpendicular required.

This depends on art. 213.

152. PROBLEM V.

To triſect, or divide into three equal parts, a right angle A B C.



OPERATION, 1ſt. From B with any radius deſcribe the arc A C.

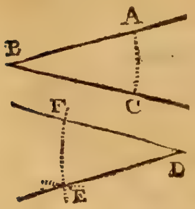
2d. From A and C with the ſame radius, cut the arc A C in E and D.

3d. Draw B E, B D, and the angle A B C will be divided into three equal parts.

This depends on art. 267.

153. PROBLEM VI.

At a given point D, *to make right lined angle equal to a given right lined angle* A B C.



OPERATION, 1ſt. From B and D with one radius deſcribe the arcs A C, E F.

2d. Lay the diſtance A C on the arc E F from F to E.

3d. Lines drawn from D, thro' E and F, will form the angle E D F equal to the angle A B C.

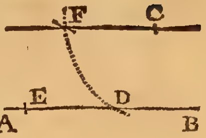
This depends on art. 191.

154. PROBLEM VII.

To draw a line parallel to a given right line AB.

When the parallel line is to paſs thro' a given point C.

OPERATION, 1ſt. Take any point D in the line AB; and from that point with the radius DC, cut AB in E, and from E deſcribe an arc F.



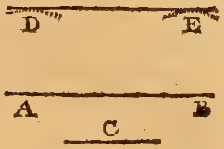
2d. From C, with the ſame radius CD, cut the arc in F.

3d. A line drawn thro' F and C will be parallel to AB.

This depends on art. 191, 185.

155. *When the parallel line is to be at the given diſtance* C *from* AB.

OPERATION, 1ſt. From the points A and B, with the radius C, deſcribe arcs D and E.



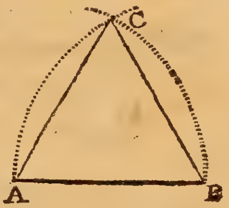
2d. Lay a ruler to touch the arcs D and E, and a line drawn in that poſition is the parallel required.

This operation is mechanical.

156 PROBLEM VIII.

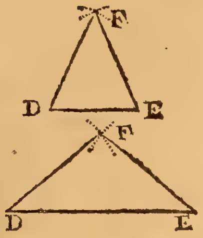
Upon a given line AB, *to make an equilateral triangle.*

OPERATION, 1ſt. From the points A and B, with the radius AB, deſcribe arcs cutting in C.



2d. Draw CA, CB, and the figure ABC is the the triangle required.

The truth of this operation is evident; for the ſides are radii of equal circles.

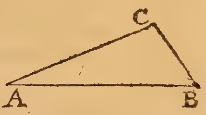


157. By a like operation, may an Iſoſceles triangle DEF be conſtructed on a given baſe DE, with the given equal legs DF, EF.

158. PROBLEM IX.

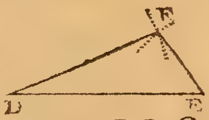
To make a right lined triangle whoſe ſides ſhall be reſpectively equal to thoſe of a given triangle ABC; *or to three given lines, provided any two of them taken together are greater than the third.*

OPERATION, 1ſt. Draw a line DE equal to the line AB.



2d. On D, with a radius equal to AC, deſcribe an arc F.

3d. On E with a radius equal to BC, deſcribe an arc cutting the arc F in F.

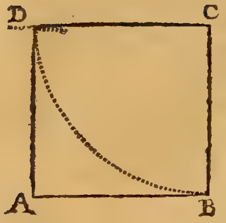


4th. Draw FD, FE, and the triangle DFE will be that required.

159.

PROBLEM X.

Upon a given line AB, *to deſcribe a ſquare.*

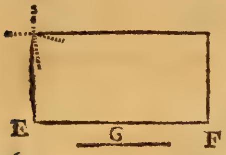


OPERATION, 1ſt. Draw BC perpendicular and equal to AB. (149).

2d. On A and C, with the radius AB, deſcribe arcs cutting in D.

3d. Draw DC, DA; and the figure ABCD is the ſquare required.

This depends on art. 191, 194, 185, 121.

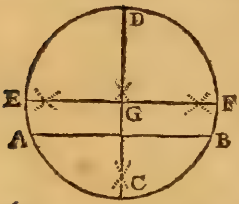


160. By a like operation a rectangle may be deſcribed, whoſe length ſhall be equal to the given line EF, and the breadth equal to the given line G.

161.

PROBLEM XI.

To find the centre of a circle.



OPERATION, 1ſt. Draw any chord AB.

2d. Biſect AB with the chord CD. (146).

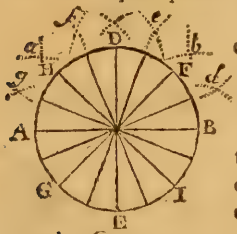
3d. Biſect CD with the chord EF, and their interſection G will be the centre required.

This depends on art. 208.

162.

PROBLEM XII.

To divide the circumference of a circle into two, four, eight, ſixteen, thirty two &c. equal parts.



OPERATION, 1ſt. A diameter AB divides the circle into two equal parts.

2d. A diameter DE perpendicular to AB, divides the circumference into four equal parts.

3d. On A, D, B, deſcribe arcs cutting in *a*, *b*; then by the interſections *a*, *b* and the centre, the diameters FG, HI, being drawn, divides it into eight equal parts.

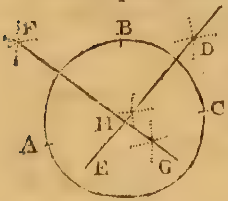
4th. On A, H, D, F, B, deſcribe arcs cutting in *g*, *f*, *e*, *d*; by theſe and the centre, diameters being drawn, divides it into ſixteen equal parts, &c.

For at each operation, the intercepted arcs are biſected.

163.

PROBLEM XIII.

To deſcribe a circle, whoſe circumference ſhall paſs thro' three given points A, B, C, *provided they do not lie in one right line.*



OPERATION, 1ſt. Biſect the diſtance CB with the line DE. (146).

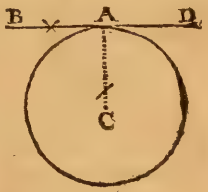
2d. Biſect the diſtance AB with the line FG.

3d. On H, the interſection of theſe lines, with the diſtance to either of the given points, deſcribe the circle required.

This depends on art. 208.

164. PROBLEM XIV.

To draw a tangent to a given circle, that ſhall paſs thro' a given point A.



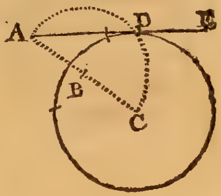
When A is in the circumference of the circle.

OPERATION, 1ſt. From the centre C, draw the radius CA.

2d. Thro' A draw BD perpendicular to CA (149). and BD is the tangent required.

This depends on art. 209.

165. When the given point A, is without the given circle.



OPERATION, 1ſt. From the centre C draw CA, which biſect (146) in B:

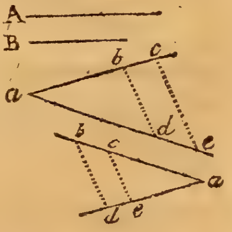
2d. On B, with the radius BA, cut the given circumference in D.

3d. Thro' D, the line AE being drawn will be the tangent required.

This depends on art. 213, 209.

166. PROBLEM XV.

To two given right lines A, B, *to find* D *a third proportional.*



OPERATION, 1ſt. Draw two right lines making any angle, and meeting in *a*.

2d. In theſe lines, take *ab* = firſt term, and *ac*, *ad* each equal to the ſecond term.

3d. Draw *bd*, and thro' *c* draw *ce* parallel to *bd*; then *ae* is the third proportional ſought.

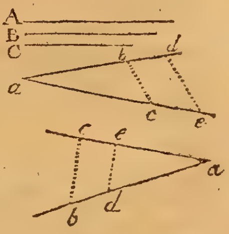
And *ab* : *ac* : : *ad* : *ae*. *

Or A : B : : B : D. And B : A : : A : D.

This depends on art. 248.

167. PROBLEM. XVI.

To three given right lines A, B, C, *to find* D *a fourth proportional.*



OPERATION, 1ſt. Draw two right lines making any angle, and meeting in *a*.

2d. In theſe lines take *ab* = firſt term, *ac* = ſecond term, and *ad* = third term.

3d. Draw *bc*, and parallel thereto thro' *d* draw *de*; then *ae* is the fourth proportional required.

And *ab* : *ac* : : *ad* : *ae*.

Or A : B : : C : D. And C : B : : A : D.

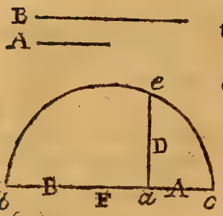
This depends on art. 248.

---

* And is thus read. *ab* is to *ac* ſo is *ad* to *ae*. The firſt : ſtands for *is to*, the laſt : for *to*, and : : for *ſo is*.

168. PROBLEM XVII.

Between two given right lines A, B, *to find* D, *a mean proportional.*



OPERATION, 1ſt. Draw a right line, in which take $ac = \text{A}$, $ab = \text{B}$.

2d. Biſect bc in F; and on F, with the radius Fb, deſcribe a circle bec.

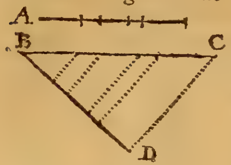
3d. From a draw ae perpendicular to bc; then ae is the mean proportional required.

And $ac : ae :: ae : ab$. Or A : D :: D : B.

This depends on art. 254.

169. PROBLEM XVIII.

To divide a given line B C *in the ſame proportion as a given line* A *is divided.*



OPERATION, 1ſt. From one end B of B C, draw B D making any angle with B C.

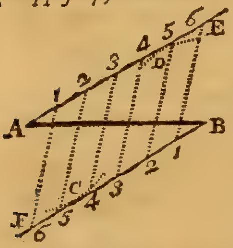
2d. In B D lay off from B, the ſeveral diviſions of A, ſo B D will be equal to A.

3d. Draw C D; then lines drawn parallel to C D thro' the ſeveral diviſions of B D, will divide the line B C in the manner required.

This depends on art. 248.

170. PROBLEM XIX.

To divide a given right line A B *into a propoſed number of equal parts (Suppoſe 7).*



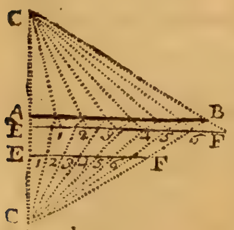
OPERATION, 1ſt. From the ends A, B, with the ſame radius, deſcribe the arcs C, D; and from A and B lines drawn to touch theſe arcs, as A E, B F, will be parallel. (155).

2d. In each of the lines A E, B F, beginning at A and B, take of any length, as many equal parts leſs one as AB is to be divided into, *viz.* 1, 2, 3, 4, 5, 6.

3d. Lines drawn from 1 to 6, 2 to 5, 3 to 4, &c. will divide AB as was required.

This depends on art. 248.

171. *Another Method.*



OPERATION, 1ſt. Thro' one end A, draw a line C C nearly perpendicular to A B.

2d. Draw E F parallel to AB, at any convenient diſtance.

3d. In E F take of any length, as many equal parts as A B is to be divided into; as 1, 2, 3, 4, 5, 6, to F.

4th. Thro' B, and F where the diviſions terminate, draw B C.

5th. Lines drawn from C thro' the ſeveral diviſions of E F, will cut AB into the equal parts required.

Note. If the diviſions from E to F chance to be leſs than AB, the point C, and the line E F will be on the ſame ſide of AB: But if greater, C falls on the contrary ſide.

172.

PROBLEM XX.

To make ſcales of equal parts.

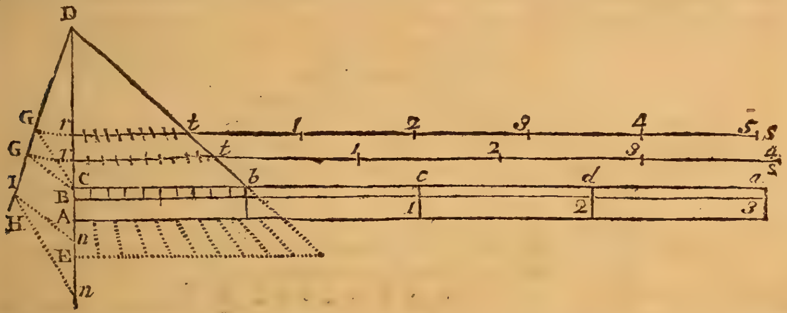
Operation, 1. Draw three lines A, B, C, parallel to one another, and at convenient diſtances, ſuch as are here expreſſed.

2d. In the line A, take the equal parts A*b*, *bc*, *cd*, *da*, &c. each equal to ſome propoſed length.

3d. Thro' A draw the line D E perpendicular to A *a*; and parallel to D E, thro' the ſeveral points *b*, *c*, *d*, *a*, &c. draw lines acroſs the three parallels A, B, C; then are the ſpaces or diſtances A *b*, *bc*, *cd*, &c. called the primary diviſions.

4th. Divide the left hand ſpace into 10 equal parts (171), and thro' theſe points let lines parallel to D E be drawn acroſs the parallels B C; and the primary diviſion A *b*, will be parted into 10 equal ſpaces called ſubdiviſions.

5th. Number the primary diviſions from the left towards the right, beginning at *c*, and the ſcale is conſtructed.



Such ſcales are uſeful for conſtructing of figures whoſe ſides are expreſſed in meaſures of length; as feet, yards, miles, &c. Or to find the meaſures of the lengths of lines in a given figure.

Thus a line of 36, or of 360, feet, yards, &c. is taken, by ſetting one point of the compaſſes on the third primary diviſion, and extending the other point to the ſixth ſubdiviſion: And ſo of others.

In theſe ſcales 'tis uſually ſuppoſed that an inch is divided into ſome number of ſuch parts, as are expreſſed by the ſubdiviſions.

173. *To find the diviſions of a ſcale of equal parts, when any given number of them are to make an inch.*

Operation, 1ſt. Make a ſcale C *a*, where the primary diviſions ſhall be each one inch; let D C be at right angles to C *a*, and the left hand ſpace C *b* be divided into 10 equal parts, and draw D *b* from any point D.

2d. Draw D H, making with D C any angle; and make D I = C *b*.

3d. Take the number of parts propoſed in an inch, from the ſcale C *a*, and lay them from D to *n*, in the line D C, continued if neceſſary.

4th. Draw *n* I, and C G parallel to *n* I; and make D *r* = D G.

5th. Thro' *r* draw *rs*; cutting D *b* in *t*; then *rt* will be one of the primary diviſions containing 10 of the parts the inch was to be divided into.

6th. Lines drawn from D to the diviſions of C *b*, divides *rt* into 10 equal parts.

174.

174. PROBLEM XXI.

To divide the circumference of a circle into degrees; and thence to make a ſcale of chords.

Operation, 1ſt. Deſcribe the ſemicircle A B D, whoſe centre is C; and draw C D at right angles to AB.

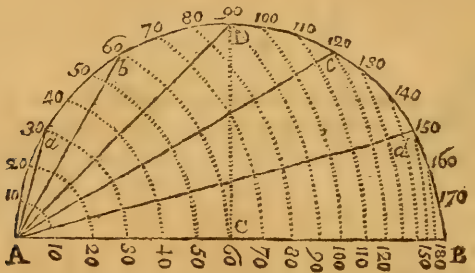
2d. Triſect the angles ACD, DCB, in the points *a*, *b*; *c*, *d*; (152), then by trials, divide the arcs A *a*, *ab*, *b* D, D *c*, *cd*, *d* B, each into three equal parts, and the ſemicircumference will be divided into 18 equal parts, of 10 degrees each.

3d. Theſe arcs being biſected, will give arcs of 5 degrees.

4th. And theſe arcs being divided into 5 equal parts, by trials, will give arcs of 1 degree each.

The like may be done with the whole circumference.

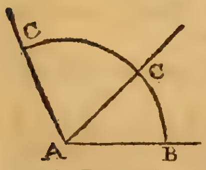
5th. The chords of the arcs A *d*, A *c*, AD, A *b*, A *a*, and of every other arc, being applied from A on the diameter AB, will divide AB into a ſcale of chords; which are to be numbered from A towards B.



A ſcale of chords is uſeful for conſtructing an angle of a given number of degrees: And for finding the meaſure of a given angle.

175. PROBLEM XXII.

To make an angle of a propoſed number of degrees.



Operation, 1. Take the firſt 60 deg. from the ſcale of chords, and with this radius deſcribe an arc BC, whoſe centre is A.

2d. Take the chord of the propoſed number of degrees from the ſcale, reckoning from its beginning, and apply this diſtance to the arc B C, from B to C.

3d. Lines drawn from A, thro' the points B and C, will form an angle BAC, whoſe meaſure is the degrees propoſed.

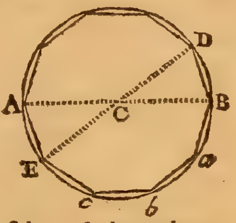
When a given angle BAC *is to be meaſured.*

From the angular point A, with the chord of 60 degrees, deſcribe the arc B C, cutting the legs in the points B and C.

Then the diſtance B C applied to the chords, from the beginning, will ſhew the degrees which meaſure the angle B A C.

176. PROBLEM XXIII.

In a given circle to inſcribe a regular polygon, the number of ſides being given.



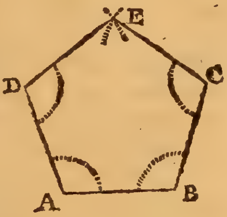
Operation, 1ſt. Divide 360 degrees by the number of ſides, and the quotient will be the degrees which meaſure the angle at the centre of the circle ſubtended by a ſide of the *polygon.*

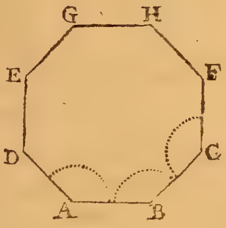
2d. Draw the radius C B, make an angle B C D equal to thoſe degrees, and draw the chord D B; then will D B be the ſide of the polygon required; which applied to the circumference from B to *a*, *a* to *b*, *b* to *c* &c. will give the points to which the ſides of the polygon are to be drawn.

If the polygon has an even number of ſides; draw the diameter A B; and divide half the circumference, as before; then lines drawn from theſe points thro' the centre as E D, will give the remaining points in the other ſemicircumference.

177. PROBLEM XXIV.

On a given right line A B, *to conſtruct a regular polygon of any aſſigned number of ſides.*





Operation, 1ſt. Divide 360 degrees by the number of ſides; ſubtract the quotient from 180 degrees, the remainder will be the degrees which meaſure the angle made by any two adjoining ſides of that polygon, and is called the angle of the polygon.

2d. At the ends A, B, of the line A B, make angles A B C, B A D, equal to the angle of the polygon.

3d. Make A D, B C, each equal to A B.

4th. At the points C, D, make angles equal to that of the polygon as before; and let the ſides including thoſe angles be each equal to A B; and thus proceed until the polygon is conſtructed.

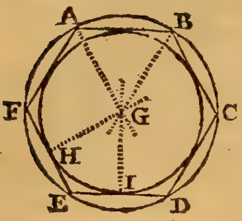
In figures of any number of ſides, the two laſt D E, C E, or E G, H G, are readieſt found by deſcribing arcs from C and D, or from E and H, with the radius A B, interſecting in E, or in G.

In figures of an even number of ſides, having drawn half the number, A D, A B, B C, C F, by means of the angles; the remaining ſides may be found by drawing thro' the points D and F, the lines D E, F H, parallel and equal to their oppoſite ſides C F, A D; and ſo of the reſt.

178.

178. PROBLEM XXV.

About a given Regular Polygon, to circumſcribe a circle: Or, within that Polygon to inſcribe a circle.



Operation, 1ſt. Biſect any two angles FAB, CBA, with the lines AG, BG, and the point G where they interſect one another will be the centre of the polygon.

2d. A circle deſcribed from G, with the radius GA, will circumſcribe the given polygon.

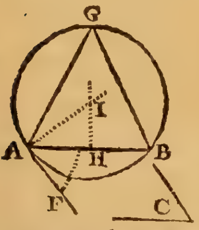
179. Or, 1ſt. Biſect any two ſides FE, ED, in the points H and I; and draw HG, IG, at right angles to FE, ED; then the point G where they interſect each other, will be the centre of the polygon.

2d. A circle deſcribed from G, with the radius GH, will be inſcribed in the given polygon.

This depends on art. 209.

180. PROBLEM XXVI.

On a given right line (AB), *to deſcribe a ſegment of a circle, that ſhall contain an angle equal to a given right lined angle* (C).



Operation, 1ſt. Make an angle BAF equal to the given angle C. (153)

2d. From H, the middle of AB, draw HI at right angles to AB, and from A, draw AI at right angles to AF, cutting HI in I.

3d. From I, with the radius IA, deſcribe a circle.

Then will the ſegment AGB contain an angle AGB equal to the given angle C.

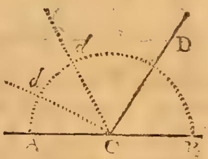
This depends on art. 208, 209, 215.

SECTION III.

GEOMETRICAL THEOREMS.

OF PLANES.

181. THEOREM I.

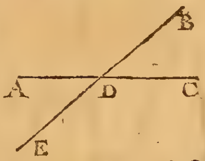


When one right line (CD) *ſtands upon another right line* (AB), *they make two angles* (ECD, ACD) *which together are equal to two right angles.*

DEMONSTRATION. For deſcribing a ſemicircle ADB, on C. (136)
Then the arc DB meaſures the angle BCD. (106)
And the arc DA meaſures the angle ACD. (106)
But the arcs DB and AD together meaſure two right angles. (104, 107)
Therefore BCD and ACD together, are equal to two right angles. (141)

182. COROLLARY. Hence if ever ſo many right lines (C *d*) ſtand on one point (C), on the ſame ſide of another right line (AB); the ſum of all the angles are equal to two right angles; or are meaſured by 180 degrees.

183. THEOREM II.

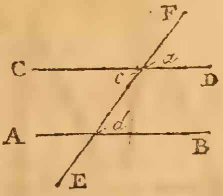


If two right lines (AC, EB) *interſect each other* (*in* D), *the oppoſite angles are equal, viz.* ∠ CDB = ∠ ADE, alſo ∠ CDE = ∠ ADB.

DEM. For ∠ ADE + ∠ ADB = two right angles. (181)
And ∠ CDB + ∠ ADB = two right angles. (181)
Therefore ∠ ADE + ∠ ADB = ∠ CDB + ∠ ADB. (137)
Conſequently ∠ ADE = ∠ CDB. (139)

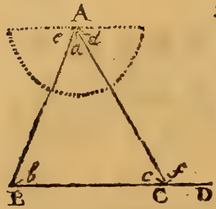
184. COROL. Hence if ever ſo many right lines croſs each other in one point, the ſum of all the angles which they make about that point, are equal to four right angles; or are meaſured by 360 degrees.

185. THEOREM III.



If a right line (FE) *cut two parallel right lines* (AB, CD); *then is the outward angle* (*a*) *equal to the inward and oppoſite angle* (*d*); *and the alternate angles* (*c*, *d*) *are equal: and the contrary.*

DEM. Becauſe CD and AB are parallel by ſuppoſition:
Then FE has the ſame inclination to CD and AB. (144)
And this inclination is expreſſed by the ∠ *a* or ∠ *d*: (105)
Therefore the outward ∠ *a* is equal to the inward and oppoſite ∠ *d*.
Now the ∠ *a* is equal to the ∠ *c*, (183)
And ſince the ∠ *a* is equal to the ∠ *d*;
Therefore the alternate angles *c* and *d* are equal. (137)



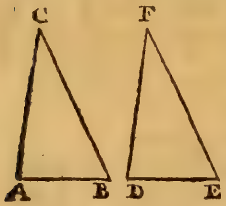
186. THEOREM IV.

In any right lined triangle (ABC), *the ſum of the three angles* (a, b, c,) *are equal to two right angles: And if one ſide* (BC) *be continued, the outward angle* (f) *is equal to the ſum of the two inward and oppoſite angles* (a, b).

DEM. Thro' A, draw a right line parallel to BC. (154) making with AB the $\angle e$, and with AC the angle d.
Then $\angle e + \angle a + \angle d =$ two right angles. (182)
And $\angle e = \angle b$; alſo $\angle d = \angle c$. (185)
Therefore $\angle b + \angle a + \angle c = \angle e + \angle a + \angle d$. (138)
Conſequently $\angle b + \angle a + \angle c =$ two right angles. (137)
Alſo $\angle c + \angle f =$ two right angles. (181)
Therefore $\angle f = \angle a + \angle b$. (137)

187. Hence, if one angle is right or obtuſe, each of the others is acute.

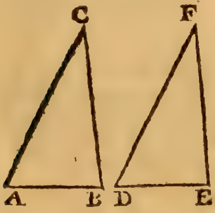
188. If two angles of one triangle are equal to two angles of another triangle, the remaining angles are equal. And if one angle in one triangle is equal to one angle in another triangle, then is the ſum of the remaining angles in one, equal to the ſum of the remaining angles in the other.



189. THEOREM V.

If two ſides (AB, AC) *and the included angle* (A) *in one triangle* (ABC), *are reſpectively equal to two ſides* (DE, DF) *and the included angle* (D) *of another* (DEF), *each to each; then are thoſe triangles congruous.*

DEM. Apply the point D to the point A, and the line DE to AB.
Now as DE = AB (by ſuppoſition); therefore the point E falls on B.
But $\angle$ D = $\angle$ A (by ſup.); therefore DF will fall on AC.
And ſince DF = AC; therefore the point F falls on C.
Conſequently FE will fall on CB.
Therefore the triangles ACB, DFE, are congruous; ſince every part agrees.



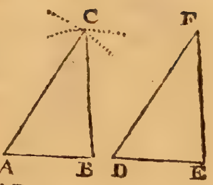
190. THEOREM VI.

If two triangles (ABC, DEF) *have two angles* (A, B) *and the included ſide* (AB) *in one, reſpectively equal to two angles* (D, E) *and the included ſide* (DE) *in the other, each to each; then are thoſe triangles congruous.*

DEM. Apply the point D to A, and the line DE to AB.
Now as DE = AB (by ſup.); therefore the point E falls on B.
And as $\angle$ D = $\angle$ A (by ſup.) therefore the line DF falls on AC.
Now if the line AC is leſs or greater than the line DF;
Then the line FE not falling on CB, makes the $\angle$ B leſs or greater than $\angle$ E.
But $\angle$ B = $\angle$ E (by ſup.); therefore AC is neither leſs nor greater than DF.
Or the line AC = DF; conſequently FE = CB.
Therefore the triangles are congruous.

191. THEOREM VII.

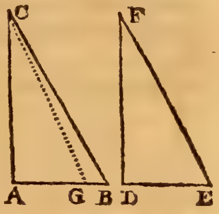
Two triangles (ABC, DEF) *are congruous, when the three ſides in the one, are equal to the three ſides in the other, each to each.*



DEM. Apply the point D to A, and the line DE to AB.
Now as DE = AB (by ſup.); therefore the point E falls on B.
On A, with the radius AC deſcribe an arc.
Then as DF = AC, the point F will fall in that arc.
Alſo on B with the radius BC deſcribe another arc, cutting the former.
And ſince EF = BC, the point F will fall in this arc.
But the point F can be only where theſe arcs interſect, as in C.
Conſequently the triangles are congruous.

192. THEOREM VIII.

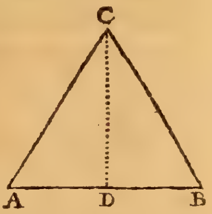
Two triangles (ABC, DEF) *are congruous, when two angles* (A, B) *and a ſide* (AC) *oppoſite to one of them, in one triangle; are reſpectively equal to two angles* (D, E) *and a ſide* (DF) *oppoſite to a like angle in the other triangle, each to each.*



DEM. Apply the point D to A, and the line DF to AC.
Now as DF = AC (by ſup.), therefore the point F falls on C.
And as ∠ D = ∠ A (by ſup.), the line DE will fall on the line AB.
And if the point E does not fall on B, ſuppoſe it falls on any other point G, and draw CG.
Then the angle AGC is equal to the angle DEF. (189)
And the ∠ ABC = (DEF =) AGC, which is not true. (186)
Therefore the point E can fall no where but on the point B.
Conſequently the triangles are congruous.

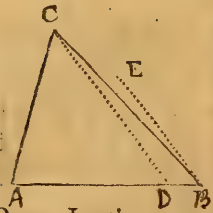
193. THEOREM IX.

In an Iſoſceles, or Equilateral triangle (ABC); *a line drawn from the vertex* (C) *to the middle of the baſe* (AB), *is perpendicular to the baſe, and biſects the vertical angle: and the contrary.*



DEM. The triangles ADC, BDE, are congruous,
Since CA = CB (114); CD = CD, and AD = DB by ſuppoſition:
Therefore ∠ A = ∠ B, ∠ ACD = BCD, ∠ ADC = ∠ BDC. (191)
Conſequently CD is at right angles to AB. (108)

194. COROL. Hence in any right lined triangle, where there are equal ſides, or angles;
The angles (A, B,) oppoſite to equal ſides (BC, AC,) are equal.
And the ſides (BC, AC,) oppoſite to equal angles (A, B,) are equal.

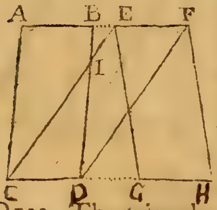


195. THEOREM X.

In every right lined triangle (ABC), *the greateſt angle* (C) *is oppoſite to the greateſt ſide* (AB).

DEM. In the greateſt ſide AB, take $AD = AC$, draw CD, and thro' B draw BE parallel to CD.
Then the angles ADC, ACD, are equal. (194)
And $\angle ADC = \angle ABE$. (185)
Therefore $\angle ACD = \angle ABE$. (137)
That is, a part of the angle ACB is greater than the angle ABC.
Conſequently the $\angle C$ is greater than the $\angle B$; and in the ſame manner, it will be found to be greater than the $\angle A$.

196. COROL. Hence in every right lined triangle, the greateſt ſide is oppoſite to the greateſt angle.

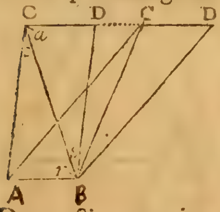


197. THEOREM XI.

Parallelograms (AD, DE, EH) *ſtanding on the ſame baſe* (CD), *or on equal baſes* (CD, GH), *and between the ſame parallels,* (CH, AF), *are equal.*

DEM. The triangles ACE, BDF, are congruous. (191)
For $AC = BD$, $CE = DF$ (119); and $AE = (AB + BE =)\ BF (= EF + BE)$.
Now if from each of the triangles ACE and BDF, be taken the triangle BIE, the remaining trapeziums ABIC and FEID are equal. (139)
Then if to each of the trapeziums ABIC, FEID, be added the triangle CID, their ſum will be the parallelograms AD and DE, which are equal. (138)

And in like manner it may be ſhewn, that the parallelogram EH is equal to the parallelogram $ED = AD$.



198. THEOREM XII.

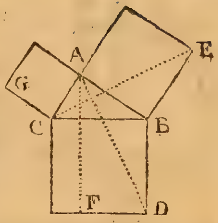
A triangle (ABC) *is the half of a parallelogram* (AD), *when they ſtand on the ſame baſe* (AB), *and are between the ſame parallels* (AB, CD).

DEM. Since CB is a diagonal to the parallelogram AD, and cuts the parallels AB, CD, and CA, DB.
Then $\angle a = \angle r$, and $\angle c = \angle s$. (185)
And $\angle r$, CB, $\angle c$, are reſpectively equal to $\angle a$, CB, $\angle s$.
Therefore the triangles ABC and BCD are congruous. (190)
Conſequently the triangle ABC is half the parallelogram AD.

199. COROL. I. Hence every parallelogram is biſected by its diagonal.

200. II. Alſo, triangles ſtanding on the ſame baſe, or on equal baſes, and between the ſame parallels are equal.
They being the halves of equal parallelograms under like circumſtances.

201. THEOREM XIII.



In every right angled triangle (BAC), *the ſquare on the ſide* (BC) *oppoſite to the right angle* (A), *is equal to the ſum of the ſquares of the two ſides* (AB, AC) *containing the right angle.*

DEM. On the ſides AB, AC, BC, conſtruct the ſquares AG, AE, CD (159); draw AD, CE; and draw AF parallel to BD. (154)
Then the triangles ABD, EBC, are congruous. (189)
For the ∠ ABE = ∠ CBD, being right angles. (121)
To each add the angle ABC, and ∠ EBC and ∠ ABD are equal. (138)
Therefore EB, BC, ∠ EBC, are reſpectively equal to AB, BD, ∠ ABD.
Alſo the triangle EBC is half the parallelogram AE. (198)
For they ſtand upon the ſame baſe EB, and are between the ſame parallels EB and AC, BA making right angles with BE and CA continued.
Likewiſe the triangle ABD is half the parallelogram BF. (198)
For they ſtand upon the ſame baſe BD, and are between the ſame parallels BD, AF.
Therefore, as the halves of the parallelograms EA and BF are equal, conſequently the parallelogram BF is equal to the ſquare AE. (140)
In the ſame manner may it be ſhewn, that the parallelogram CF is equal to the ſquare AG.
But the parallelograms BF and CF together, make the ſquare CD.
Therefore the ſquare CD is equal to the ſquares EA and AG.

202. COROL. I. Hence if any two ſides of a right angled triangle are known, the other ſide is alſo known.

For BC = ſquare root of the ſum of the ſquares of AC and AB.
AC = ſquare root of the difference of the ſquares of BC and AB.
AB = ſquare root of the difference of the ſqures of BC and AC.

203. Or thus, making the quantities $\overline{BC}^2$, $\overline{AB}^2$, $\overline{AC}^2$, to ſtand for the ſquares made on thoſe lines.

And the mark $\sqrt{}$ to ſtand for the ſquare root of ſuch quantities as ſtand under a line joined to the top of this mark.

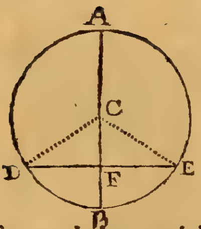
Then $BC = \sqrt{\overline{AC}^2 + \overline{AB}^2}$; $AC = \sqrt{\overline{BC}^2 - \overline{AB}^2}$; $AB = \sqrt{\overline{BC}^2 - \overline{AC}^2}$.

204. COROL. II. Of all the lines drawn from a given point to a given ine, the perpendicular is the ſhorteſt.

205. COROL. III. The ſhorteſt diſtance between two parallel right lines, is a right line drawn from one to the other perpendicular to both.

206. COROL. IV. Parallel right lines are equidiſtant; and the contrary. For two oppoſite ſides of a rectangular parallelogram are equal (119); and each is the ſhorteſt diſtance between the other ſides.

207.

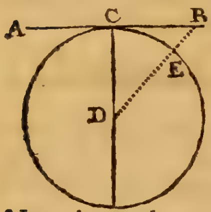


207. THEOREM XIV.

In any circle, a diameter (AB) *drawn perpendicular to a chord* (DE), *biſects that chord and its ſubtended arc* (DBE).

DEM. From the centre C, draw the radii CD, CE, to the extremities of the chord DE.
Then the triangle CFE, CFD, are congruous. (192)
For CF being at right angles to DE, the ∠ CFD = ∠ CFE. (108)
And the triangle CDE being Iſoſceles (114), the ∠ D = ∠ E (194). Alſo CF is common.
Therefore DF = FE: And the arc DB = BE.
For thoſe arcs meaſure the equal angles FCE, FCD. (143)

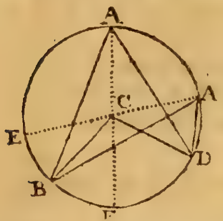
208. COROL. Hence, in a circle, a right line drawn thro' the middle of a chord at right angles to it, paſſes thro' the centre of that circle; and the contrary.



209. THEOREM XV.

A tangent (AB) *to a circle, is perpendicular to a diameter* (DC) *drawn to the point of contact* (C).

DEM. If it be denied that DC is perpendicular to AB. Then from the centre D, let ſome other line DB, cutting the circle in E, be drawn perpendicular to AB.
Now the angle DBC being right, the angle DCB is acute. (187)
And DC = DE, is greater than DB (196), which is abſurd.
Therefore no other line paſſing thro' the centre can be perpendicular to the tangent, but that which meets it at the point of contact.



210. THEOREM XVI.

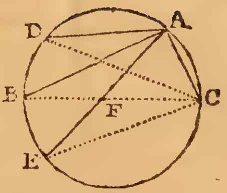
An angle (BCD) *at the centre of a circle, is double to the angle* (BAD) *at the circumference, when thoſe angles ſtand on the ſame arc* BD).

DEM. Thro' the point A draw the diameter AE.
Then the angle ECD = ∠ CAD + ∠ CDA. (186)
But the ∠ CAD = ∠ CDA. (194)
Therefore the ∠ ECD is equal to twice the angle CAD.
In the ſame manner it may be ſhewn, that the angle BCE is equal to twice the angle BAE.
Conſequently the angle BCD (= ∠ BCE + ∠ ECD) is equal to twice the angle BAD (= ∠ BAE + ∠ EAD). (138)

211. COROL. I. Hence an angle (BAD) at the circumference is meaſured by half the arc (BD) on which it ſtands.
For the angle at the centre (BCD) is meaſured by the arc BD. (106)
Conſequently the angle BAD = half the angle BCD, is meaſured by half the arc BD.

212. II. All angles in the circumference and ſtanding on the ſame arc are equal.

213. THEOREM XVII.



An angle (BAC) *in a ſemicircle, is a right one.*

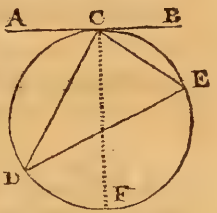
An angle (DAC) *in a ſegment leſs than a ſemicircle, is obtuſe.*

An angle (EAC) *in a ſegment greater than a ſemicircle, is acute.*

DEM. For the angle BAC is meaſured by half the ſemicircular arc BEC, which is equal to 180 degrees. (211)
And ∠ DAC is meaſured by half the arc DEC, greater than 180°.
Alſo ∠ EAC is meaſured by half the arc EC, leſs than 180°.
Therefore theſe angles are reſpectively equal to, greater, or leſs than 90 degrees.

214. COROL. Hence in a right angled triangle (BAC); the angular point (A) of the right angle, and the ends (B, C) of the oppoſite ſide, are equally diſtant from (F) the middle of that ſide; that is, a circle will always paſs thro' the right angle and the ends of its oppoſite ſide taken as a diameter.

215. THEOREM XVIII.

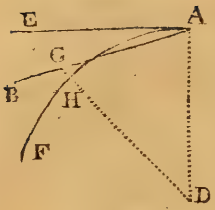


The angle (ACD) *formed by a tangent* (AB) *to a circle* (CDE), *and a chord* (CD) *drawn from the point of contact* (C), *is equal to an angle* (CED) *in the alternate ſegment.*

DEM. Draw the diameter CF; then ∠ ACF is right. (209)
Therefore the ∠ ACF is meaſured by half the arc CDF. (107)
But the angle DCF is meaſured by half the arc DF. (211)
Therefore ∠ ACD (= ∠ ACF — ∠ DCF) is meaſured by half the arc DC (= CDF — DF).
And ∠ CED is meaſured by half the arc CD. (211)
Therefore ∠ ACD = ∠ CED. (141)

---

* A ſmall ° put above any figure, ſignifies degrees.



216. THEOREM XIX.

Between a circular arc (AHF) *and its tangent* (AE), *no right line can be drawn from the point of contact* (A).

DEMON. For if any other right line can be drawn, let it be the right line AB.
From D the centre of AHF, draw DG perpendicular to AB, cutting AB in G, and the arc in H.
Now as ∠ DGA is right; therefore DA is greater than DG. (196)
But DA = DH (100). Therefore DH is greater than DG, which is abſurd.
Conſequently no right line can be drawn between the tangent AE and the arc AHF.

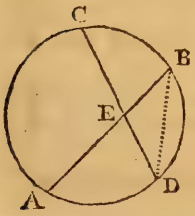
217. COROL. I. Hence the angle DAH, contained between the radius DA, and an arc AH, is greater than any right lined acute angle.

For a right line AB muſt be drawn from A, between the tangent AE and radius AD, to make an acute angle.

But no ſuch right line can be drawn between AE and the arc AH.

218. COROL. II. Hence the angle EAH, between the tangent EA and arc AH, is leſs than any right lined acute angle.

219. COROL. III. Hence it follows, that at the point of contact, the arc has the ſame direction as the tangent, and is at right angles to the radius drawn to that point.



220. THEOREM XX.

If two right lines (AB, CD) *interſect any how* (*in* E) *within a circle*; *their inclination* (AED, *or* CEB) *is meaſured by half the ſum of the intercepted arcs* (AD, CB).

DEM. For drawing DB;
The ∠ AED = ∠ EDB + ∠ EBD. (186)
But the ∠ EDB is meaſured by $\frac{1}{2}$ arc CB. (211)
And the ∠ EBD is meaſured by $\frac{1}{2}$ arc AD. (211)
Conſequently the ∠ AED is meaſured by half the arc CB together with half the arc AD.

SECTION IV.

OF PROPORTION.

Definitions and Principles.

221. *One quantity* A, *is ſaid to be meaſured or divided by another quantity* B, *when* A *contains* B *ſome number of times.*

Thus, if A = 20, and B = 5; then A contains B four times.
A is called a multiple of B; and B is ſaid to be a part of A.

222. *If a quantity* A (= 20) *contains another* B (= 5) *as many times as a quantity* C (= 24) *contains another* D (= 6); *then*
A *and* C, *are called like multiples of* B *and* D.
B *and* D, *are called like parts of* A *and* C: *And*
A *is ſaid to have the ſame relation to* B, *as* C *has to* D.

Or, like multiples of quantities are produced, by taking their Rectangle, or Product, by the ſame quantity, or by equal quantities.

The Rectangle or Product of quantities (A & B) is expreſſed by writing this mark × between them. Thus A × B, or B × A.

223. *When two quantities of a like kind are compared together, the relation which one of them has to the other in reſpect to quantity, is called Ratio.*

The firſt term of a ratio, or the quantity compared, is called the antecedent; and the ſecond term, or the quantity compared to, is called the Conſequent.

A ratio is uſually denoted by ſetting the antecedent above the conſequent with a line drawn between them.

Thus $\frac{A}{B}$ ſignifies, and is thus to be read, the ratio of A to B.

The multiple of a ratio $\frac{A}{B}$, is the product of each of its terms by the ſame quantity, or by equal quantities. Thus $\frac{A \times C}{B \times C}$ is the ratio $\frac{A}{B}$ taken C times.

The product of two, or more ratios, $\frac{A}{B}, \frac{C}{D}$ is expreſſed by taking the product of the antecedents for a new antecedent, and the product of the conſequents for a new conſequent. Thus $\frac{A \times C}{B \times D} = \frac{A}{B} \times \frac{C}{D}$.

224. *Equal ratios are thoſe where the antecedents are like multiples or parts of their reſpective conſequents.*

Thus in the quantities A, B, C, D: Or 20, 5, 24, 6.

In the ratio of A to B, or of 20 to 5, the antecedent is a multiple of its conſequent four times.

And in the ratio of C to D, or of 24 to 6, the antecedent is a multiple of its conſequent four times.

That is the ratio of A to B is the ſame as the ratio of C to D.

And this equality of ratios is thus expreſſed $\frac{A}{B} = \frac{C}{D}$.

225. *Ratio of equality is, when the antecedent is equal to the conſequent.*

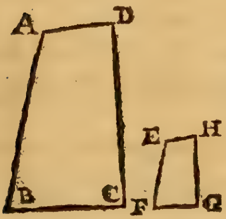
226. *Four quantities are ſaid to be proportional, which when compared together by two and two, are found to have equal ratios.*

Thus, let the quantities to be compared be A, B, C, D: Or 20, 5, 24, 6.
Now in the ratio of A to B, or of 20 to 5; A contains B four times.
And in the ratio of C to D, or of 24 to 6; C contains D four times.
Then the ratios of A to B, and of C to D, are equal: Or $\frac{A}{B} = \frac{C}{D}$. (224)
And their proportionality is thus expreſſed $A : B :: C : D$. (166)
Alſo, in the ratio of A to C, or of 20 to 24; C contains A, once and $\frac{1}{6}$.
And in the ratio of B to D, or of 5 to 6; D contains B, once and $\frac{1}{6}$.
Where the ratios are likewiſe equal, *viz.* $\frac{A}{C} = \frac{B}{D}$.
And theſe are alſo proportional $A : C :: B : D$.

227. *So that when four quantities of the ſame kind are proportional, the ratio between the firſt and ſecond, is equal to the ratio between the third and fourth; and this proportionality is called Direct.*

228. *Alſo the ratio between the firſt and third, is equal to the ratio between the ſecond and fourth; and this proportionality is called Alternate.*

229. *Similar, or like, right lined figures, are ſuch which are equiangular,* (that is, whoſe ſeveral angles are equal one to the other); *and alſo, the ſides about the equal angles proportional.*



Thus if the figures AC and EG are equiangular,
And $AB : BC :: EF : FG$; Or $BC : CD :: FG : GH$.
Then are thoſe figures called ſimilar or like figures.
And the like in Triangles, or other figures.

230. *Like arcs, chords, or tangents, in different circles, are thoſe which ſubtend, or are oppoſite to, equal angles at the centre.*

231. THEOREM XIX.

Quantities and their like multiples, have the ſame ratio.

That is, the ratio of A to B, is equal to the ratio of twice A to twice B, of thrice A to thrice B, &c. Or thus $\frac{A}{B} = \frac{2A}{2B} = \frac{3A}{3B}$ &c. $= \frac{C \times A}{C \times B}$.

Dem. For the ratio of A to B, muſt either be equal to the ratio of like multiples of A and B, or to the ratio of unlike multiples of them.
Now ſuppoſe the ratio of A to B is equal to the ratio of their unlike multiples, $C \times A$, $D \times B$; that is $\frac{A}{B} = \frac{C \times A}{D \times B}$.
Then $A : B :: C \times A : D \times B$ (227). And $A : C \times A :: B : D \times B$ (228).
Therefore $\frac{A}{C \times A} = \frac{B}{D \times B}$ (226). Where the conſequents are unequal multiples of their antecedents, by ſuppoſition.
But $\frac{A}{C \times A}$ is not equal to $\frac{B}{D \times B}$. (224)
Then $A : C \times A :: B : D \times B$ is not true.
Alſo $A : B :: C \times A : D \times B$ is not true.
Conſequently $\frac{A}{B}$ is unequal to $\frac{C \times A}{D \times B}$.
Therefore the ratio of unlike multiples of two quantities, is not equal to the ratio of thoſe quantities.
Conſequently the ratio of two quantities, and the ratio of their like multiples are the ſame. Or $\frac{A}{B} = \frac{C \times A}{C \times B}$.

232. Corol. I. In any ratio, if both terms contain the ſame quantity or quantities; the value of the ratio will not be altered by omitting, or taking away, thoſe quantities. For $\frac{C \times A}{C \times B} = \frac{A}{B}$. by taking away C.

233. II. Quantities, and their like parts have equal ratios.
For A and B are like parts of $C \times A$ and $C \times B$.

234. III. Quantities, and their like multiples, or like parts are proportional. For $A : B :: C \times A : C \times B$. And $C \times A : C \times B :: A : B$.

235. IV. If quantities are equal, their like multiples, or like parts are alſo equal. For if $A = B$; and $\frac{A}{B} = \frac{C \times A}{C \times B}$.
Then are the antecedents and conſequents in a ratio of equality. (224)

236. V. If the parts of one quantity, are proportional to the parts of another quantity, they are like parts of their reſpective quantities.
For only like parts are proportional to their wholes. (234)

237. VI. Ratios, which are equal to the ſame ratio, are equal to one another. For the ratio of $\frac{A}{B} = \frac{C \times A}{C \times B} = \frac{D \times A}{D \times B}$. &c. (231)

238. VII. Proportions, which are the ſame to the ſame proportion, are the ſame to one another.

If $A : B :: C : D$; and $A : B :: E : F$; Then $C : D :: E : F$.

For $\frac{A}{B} = \frac{D}{C}$; and $\frac{A}{B} = \frac{E}{F}$ (226). Then $\frac{C}{D} = \frac{E}{F}$. (137)

239. VIII. If two ratios or products are equal, their like multiples, either by the ſame or by equal quantities, or by equal ratios, are alſo equal.

That is, If $\frac{A}{B} = \frac{C}{D}$: Then $\frac{A \times E}{B \times E} = \frac{C \times E}{D \times E}$.

And if $E = F$: Then $\frac{A \times E}{B \times E} = \frac{C \times F}{D \times F}$.

And if $\frac{E}{F} = \frac{G}{H}$: Then $\frac{A \times E}{B \times F} = \frac{C \times G}{D \times H}$.

For in either caſe, the ratios may be conſidered as quantities.

240. THEOREM XX.

Equal quantities (A *and* B) *have the ſame ratio or proportion to another quantity* (C). *And any quantity has the ſame ratio to equal quantities.*

That is, If $A = B$: Then $A : C :: B : C$. And $C : A :: C : B$.

Dem. Since $A = B$; then C is the like multiple or part of B, as it is of A.
And $A : B :: C : C$ (234). Therefore $A : C :: B : C$ (228).
Alſo $C : C :: A : B$ (234). Therefore $C : A :: C : B$ (228).

241. Corol. I. Hence, When the antecedents are equal, the conſequents are equal; and the contrary.

242. II. Quantities are equal, which have the ſame ratio to another quantity; or to like multiples or parts of another quantity.
Thus, if $A : C :: B : C$. Then $A = B$.

243. III. Since $A : C :: B : C$ and $C : A :: C : B$. Therefore when four quantities are in proportion, As antecedent is to conſequent, ſo is antecedent to conſequent: Then ſhall the firſt conſequent be to its antecedent, as the ſecond conſequent to its antecedent; And this is called *the invertion of ratios.*

244. THEOREM XXI.

In two, or more, ſets of proportional quantities, the rectangles under the like terms are proportional.

That is, If $A : B :: C : D$; and $E : F :: G : H$.
Then $A \times E : B \times F :: C \times G : D \times H$.

Dem. Since $\frac{A}{B} = \frac{C}{D}$; And $\frac{E}{F} = \frac{G}{H}$. (227)

Therefore $\frac{A \times E}{B \times F} = \frac{C \times G}{D \times H}$. (239)

Conſequently $A \times E : B \times F :: C \times G : D \times H$. (226)

245.

THEOREM XXII.

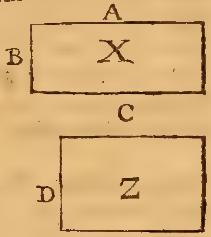
In four proportional quantities $A : B :: C : D$. *Then the Rectangle or Product of the two extremes, is equal to the Rectangle or Product of the two means.* That is $A \times D = B \times C$.

DEM. Since $A : B :: C : D$ by ſuppoſition. Therefore $\frac{A}{B} = \frac{C}{D}$ (227).

And $\frac{A}{B} = \frac{A \times D}{B \times D}$ (239). Alſo $\frac{C}{D} = \frac{C \times B}{D \times B}$. (239).

Therefore $\frac{A \times D}{B \times D} = \frac{C \times B}{D \times B}$ (137). Where the conſequents are equal.
Conſequently $A \times D = C \times B$ (241).

246. Hence, If the Rectangle or product of two quantities, is equal to the Rectangle or product of other two quantities; thoſe four quantities are proportional.
Thus, ſuppoſe the two rectangles X, Z, are equal.
Where A, C, are their lengths, and B, D, their breadths.



Then $A \times B = C \times D$ by ſuppoſition.
Therefore $A : C :: D : B$.
That is, As the length of X is to the length of Z.
So the breadth of Z is to the breadth of X.

In ſuch caſes, the lengths are ſaid to be to one another reciprocally as their breadths.
Or that the proportion $A : C :: D : B$ is reciprocal when $A \times B = C \times D$.

247.

THEOREM XXIV.

If four quantities are proportional; then will either of the extremes, and the ratio of the product of the means to the other extreme, be in a ratio of equality: And either mean, and the ratio of the product of the extremes to the other mean, will be alſo in a ratio of equality.

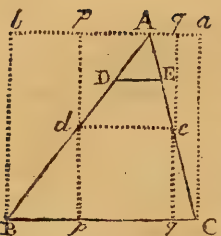
That is, If $A : B :: C : D$. Then $A = \frac{B \times C}{D}$. And $B = \frac{A \times D}{C}$.

DEM. Since $A : B :: C : D$ by ſuppoſition.
Therefore $A \times D = B \times C$ (245).

And $\frac{A \times D}{C} = \frac{B \times C}{C}$ (240). Alſo $\frac{B \times C}{D} = \frac{A \times D}{D}$ (240).

But $B = \frac{B \times C}{C}$ (232). And $A = \frac{A \times D}{D}$ (232).

Therefore $\frac{A \times D}{C} = B$ And $\frac{B \times C}{D} = A$ (137).



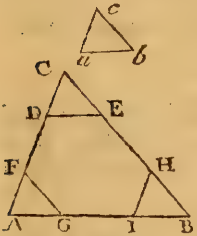
248. THEOREM. XXV.

In any plane triangle (ABC), *any two adjoining ſides* (AB, AC,) *are cut proportionally by a line* (DE) *drawn parallel to the other ſide* (BC), *viz.*
AD : DB : : AE : EC.

DEM. Thro' B and C, draw B *b* C *a* at right angles to BC, meeting *b a* drawn thro' A parallel to BC: Thro' *p*, *q*, the middles of A *b*, A *a*, draw *pp*, *qq*, parallel to B *b* or C *a*, meeting AB, AC, in the points *d c*, ; and join *d c*.
Then ſince the triangles A *dp*, B *dp*, and A *cq*, C *cq* are congruous. (190)
Therefore A *d* = B *d*, A *c* = C *c*, *p d* = *p d*, *q c* = *q c*.
But *pp* = *qq* (206): Therefore *p d* = *q c*. (140)
And *d c* is parallel to BC. (206)

In the ſame manner it may be ſhewn, that lines parallel to B *b*, drawn thro' the middles of A *p*, *p b*; A *q*, *q a*; will alſo biſect A *d*, B *d*; A *c*, C *c*; and that lines adjoining theſe points of biſection will alſo be parallel to BC: And the ſame may be proved at any other biſections of the ſegments of the lines AB, AC: Alſo the like may be readily inferred at any other diviſions of the lines A *b*, A *a*.
Therefore lines parallel to BC, cut off like parts from the lines AB, AC.
Then AB : AC : : AD : AE. And AB : AC : : BD : CE. (233)
Therefore AD : AE : : BD : CE. (238)
And by Alternation AD : BD : : AE : CE. (228)

249. COROL. Hence, When the ſides (AB, AC) of a triangle are cut proportionally (in D, E) the ſegments (AD, AE; DB, EC) of thoſe ſides are proportional to the ſides.



250. THEOREM XXVI.

In equiangular triangles (ABC, *a b c*), *the ſides about the equal angles are proportional*; *and the ſides oppoſite to equal angles are alſo proportional.*

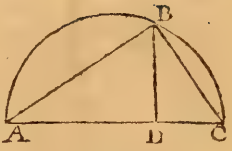
DEM. In CA, CB, take CD = *c a*, CE = *c b*; and draw DE.
Then the triangles CDE, *c a b*, being congruous. (189)
The ∠ CDE = (∠ *a* =) ∠ A. Therefore DE is parallel to AB. (185)

In the ſame manner, taking AF = *a c*, AG = *a b*; alſo BH = *b c*, BI = *b a*; and drawing FG, HI, the triangles AGF, IBH, *a b c*, are congruous; therefore FG is parallel to CB, and HI is parallel to CA.

Then (CD =) *c a* : CA : : (CE =) *c b* : CB.
(AF =) *c a* : CA : : (AG =) *a b* : AB. (242)
(BH =) *b c* : BC : : (BI =) *a b* : AB.

251. COROL. Hence, Triangles having one angle in each equal, and the ſides about thoſe equal angles proportional, thoſe triangles are equiangular and ſimilar.

252. THEOREM XXVII.



In a right angled triangle (ABC), *if a line* (BD) *be drawn from the right angle* (B) *perpendicular to the oppoſite ſide* (AC); *then will the triangles* (ABD, BCD) *on each ſide the perpendicular be ſimilar to the whole* (ABC), *and to one another.*

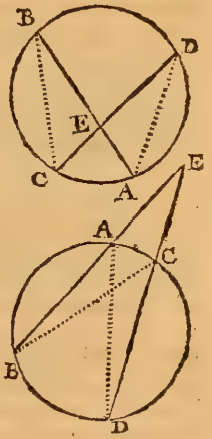
DEM. For in the triangles ABC, ADB, the $\angle A$ is common,
And the right angle ABC = right angle ADB.
Therefore the remaining $\angle C = \angle ABD$. (188)
In the ſame manner it will appear, that the triangles ABC, BDC, are like.
Therefore the triangles ABD, BCD, are alſo ſimilar.

253. COROL. I. Hence,

$$\left.\begin{array}{l} AC : AB :: AB : AD. \\ AC : BC :: BC : DC. \\ AD : DB :: DB : DC. \end{array}\right\} \qquad (250)$$

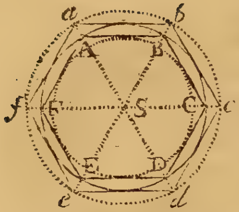
254. II. Hence a right line (BD) drawn from the circumference of a circle perpendicular to the diameter (AC) is a mean proportional between the ſegments (AD, DC) of the diameter.
And $AD \times DC = \overline{DB}^2$. (245)
For a circle whoſe diameter is AC, will paſs thro' A, B, C. (214)

255. THEOREM XXVIII.



In a circle, If two chords (AB, CD) *interſect each other* (*in* E), *either within the circle, or without by prolonging them; then the rectangle under the ſegments terminated by the circumference and their interſection, will be equal.*
That is, $AE \times EB = CE \times ED$.

DEM. Draw the lines BC, DA.
Then the triangles DEA, BEC, are ſimilar.
For the angle at E is equal (183) or common.
And the $\angle D = \angle B$, as ſtanding on the ſame arc AC (212). Then the other angles are equal. (188)
Therefore $AE : CE :: ED : EB$. (250)
Conſequently $AE \times EB = CE \times ED$. (245)



256. THEOREM XXIX.

If a regular polygon (ABCDEF) *be inſcribed in a circle; and parallel to theſe ſides if tangents to the circle be drawn, meeting one another (in the points* a, b, c, d, e, f*); then ſhall the figure formed by theſe tangents, circumſcribe the circle, and be ſimilar to the inſcribed figure.*

Dem. Since the circle touches every ſide of the figure *abcdef*, by conſtruction; therefore the circle is circumſcribed by that figure. (132)
Thro' A and B, draw the radii SA, SB, prolonged till they meet the tangent *ab*, in *a*, *b*.
Then the triangles ASB, *a*S*b*, are equiangular.
For the ∠ S is common; and the other angles are equal, becauſe AB and *ab* are parallel, by ſuppoſition.
Alſo S*a* = S*b*: For the triangles ASB, *a*S*b*, are Iſoſceles. (194)
And the ſame may be proved of the other triangles; and alſo, that they are equal to one another.
Therefore the figure *abcdef* has equal ſides, and is equiangular to the figure ABCDEF.
Now SA : S*a* : : AB : *ab*; And SA : S*a* : : AF : *af*. (250)
Therefore AB : *ab* : : AF : *af*. And the like of the other ſides. (238)
Conſequently the figures ABCDEF, *abcdef* are ſimilar.

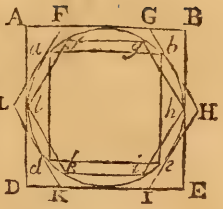
257. Corol. I. If two figures are compoſed of like ſets of ſimilar triangles, thoſe figures are ſimilar.

258. II. Hence, If from the angles (*a*, *b*) of a regular polygon circumſcribing a circle, lines (*a*S, *b*S) be drawn to the centre (S); the chords (AB) of the intercepted arcs, will be the ſides of a ſimilar polygon inſcribed in the circle; and the ſides (AB, *ab*) of the inſcribed and circumſcribing polygons will be parallel.

259. III. The chords or tangents of like arcs in different circles, are in the ſame proportion as the radii of thoſe circles.
For if a circle circumſcribe the polygon *abcdef*; then the ſides of the polygons *abcdef*, ABCDEF, are chords of like arcs in their reſpective circumſcribing circles.
And if a circle be inſcribed in the polygon ABCDEF, the ſides AB, *ab*, &c. are tangents of like arcs alſo: And theſe have been ſhewn to be proportional to their radii SA, S*a*.

260. IV. The Perimeters of like polygons (or the ſum of their ſides) are to one another as the radii of their inſcribed or circumſcribed circles.
For SA : S*a* : : AB : *ab*. (256)
And AB, *ab*, are like parts of the perimeters of their polygons.
Therefore SA : S*a* : : perim. ABCDEF : perim. *abcdef*. (234)

261. THEOREM XXX.



If there be two regular and like polygons, the one inſcribed in, and the other circumſcribing the ſame circle: Then will the circumference of that circle, and half the ſum of the perimeters of theſe polygons, approach nearer to equality, as the number of ſides in the polygons increaſe.

DEM. It is evident at ſight, that the circumſcribing hexagon FGHIKL is leſs than the circumſcribing ſquare ABED.

And alſo that the inſcribed hexagon *fghikl* is greater than the inſcribed ſquare *abed*.

And in both caſes, the difference between the hexagon and the circle, is leſs than the difference between the circle and the ſquare.

Therefore the polygon, whether inſcribed or circumſcribed, differs leſs from the circle, as the number of its ſides is increaſed.

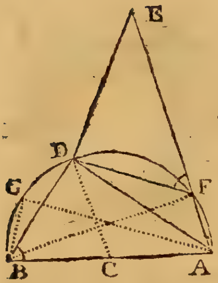
And when the number of ſides in both is very great, the perimeters of the polygons will nearly coincide with the circumference of the circle; for then the difference of the polygonal perimeters becomes ſo very ſmall, that they may be eſteemed as equal.

And yet ſo long as there is any difference between theſe polygons, tho' ever ſo ſmall, the circle is greater than the inſcribed, and leſs than the circumſcribed polygons: Therefore half their ſums may be taken for the circumference of the circle, when the number of thoſe ſides is very great.

262. Hence, The circumferences of circles are in proportion to one another, as the radii of thoſe circles, or as their diameters.

For the perimeters of the inſcribed and circumſcribing polygons are to one another as the radii of the circles. (260)

And theſe perimeters and circumferences continually approach to equality.



263. THEOREM XXXI.

In a circle (AFB), *if lines* (BA, DA, FA) *be drawn from the extremities of two equal arcs* (BD, DF) *to meet in that point* (A) *of the circumference determined by one of them* (BA) *paſſing thro' the centre; then ſhall the middle line* (AD) *be a mean proportional between the ſum* (AB + AF) *of the extreme lines, and the radius* (BC) *of that circle.*

Dem. On D with the diſtance DA, cut AF produced, in E.
Then drawing DE, DF, DB, the triangles ADB, EDF, are congruous. (192)
For ∠ EFD = (∠ FDA + ∠ FAD (186) =) ∠ DBA (211). Becauſe the arc DFA = DF + FA.
And ∠ E = ∠ FAD (194) = ∠ DAB, by conſtruction; and DE = DA.
Therefore EF = AB; and AE = AB + AF.
Draw CD; then the triangles ACD, ADE, are ſimilar.
For they are Iſoſcelar and equiangular.
Therefore AC : AD : : AD : (AE =) AB + AF. (250)

264. Hence, When the radius of the circle is expreſſed by 1, and one of the extreme lines, or chords, paſſes thro' the centre; then if the number 2 be added to the other extreme chord, the ſquare root of that ſum will be equal to the length of the mean chord.

For ſince AC : AD : : AD : AB + AF (263). Th. $\overline{AD}^2 = AC \times \overline{AB + AF}$ (245)
Now if $AC = 1$, then $AB = 2$; And $\overline{AD}^2 = 2 + AF$; becauſe multiplying by 1 is uſeleſs here. Therefore $AD = \sqrt{2 + AF}$.

As the arcs BD and DFA make a ſemicircle, they are called the ſupplements of one another: Therefore if the arc BD is any part (as $\frac{1}{3}$, $\frac{1}{6}$, $\frac{1}{12}$ &c.) of the ſemicircumference; then is the line DA called the ſupplemental chord of that part.

265. **Remark.** In the poſthumous works of the Marquis *de l'Hoſpital*, (page 319, Engliſh edition); this principle is applied to the doctrine of angular ſections; that is, to the dividing a given arc into any propoſed number of equal parts: Or to find the chord of any propoſed arc.

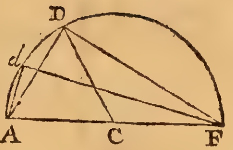
For if BF was any aſſumed arc, whoſe chord had a known ratio to the given radius BC; then as BFA is a right angled triangle (213), the ſide $AF = \sqrt{\overline{AB}^2 - \overline{BF}^2}$ (203) will alſo be known: And by this Theorem, the mean chord AD will be known; and alſo DB $(= \sqrt{\overline{AB}^2 - \overline{AD}^2})$ the chord of half the arc BF will alſo be known.

And by biſecting the arc DB in G, and drawing AG, GB; the mean chord AG is known (263); and GB $(= \sqrt{\overline{AB}^2 - \overline{AG}^2})$ is alſo given.

And in this manner by a continual biſection, the chord of a very ſmall arc may be obtained; the practice whereof is facilitated by article (264,) deduced from page 330 of the ſaid work.

266.

266. EXAMPLE. *Required the chord of the $\frac{1}{3072}$ part of the circumference of a circle whoſe radius is* 1. *Or, Required the ſide of a regular polygon of* 3072 *ſides, inſcribed in a circle whoſe diameter is* 2.



Let ADF be a ſemicircle, whoſe diameter $AF = 2$, and centre is C. Take the arc $AD = \frac{1}{3}$ of the ſemicircumference, or equal to 60 degrees; and draw DC, DA, DF.

Let d repreſent the point where the arc is biſected; dF the ſupplemental chord to that biſection: And let the marks d', d'', d''', d^{iv} &c. expreſs the biſected points agreeable to the number of biſections.

267. Now ſince $\angle ACD = 60°$; therefore $\angle CAD + \angle ADC = (180° - 60 =)\ 120°$. (188)

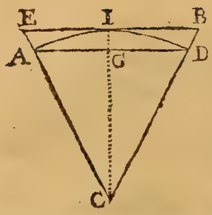
But $\angle CAD = \angle ADC$ (194); then $\angle CAD = (\frac{120°}{2} =)\ 60°$.
Therefore $DA = (DC = AC =)\ 1$.

And as the triangle ADF is right angled at D. (213)
Then $DF = (\sqrt{\overline{AF}^2 - \overline{AD}^2}$ (203) $= \sqrt{4-1} =)\ \sqrt{3} = 1{,}73205080756 88773$
Therefore the ſupplemental chord of the arc AD, or of

$\frac{1}{3}$ of the ſemicircumference is $FD = \sqrt{3} = 1{,}73205080756 88773$
$\frac{1}{6}$ of the ſame (264) is $Fd^{i} = \sqrt{2 + FD} = 1{,}93185165257 81366$
$\frac{1}{12}$ $Fd^{ii} = \sqrt{2 + Fd^{i}} = 1{,}98288972274 76208$
$\frac{1}{24}$ $Fd^{iii} = \sqrt{2 + Fd^{ii}} = 1{,}99571784647 72070$
$\frac{1}{48}$ $Fd^{iv} = \sqrt{2 + Fd^{iii}} = 1{,}99892917495 27313$
$\frac{1}{96}$ $Fd^{v} = \sqrt{2 + Fd^{iv}} = 1{,}99973227581 91236$
$\frac{1}{192}$ $Fd^{vi} = \sqrt{2 + Fd^{v}} = 1{,}99993306783 48022$
$\frac{1}{384}$ $Fd^{vii} = \sqrt{2 + Fd^{vi}} = 1{,}99998326688 87013$
$\frac{1}{768}$ $Fd^{viii} = \sqrt{2 + Fd^{vii}} = 1{,}99999581671 78004$
$\frac{1}{1536}$ $Fd^{ix} = \sqrt{2 + Fd^{viii}} = 1{,}99998954179 1767$

Now Fd^{ix} the ſupplemental chord of $\frac{1}{1536}$ being known; the chord Ad^{ix} of $\frac{1}{1536}$ part of the ſemicircumference, or of $\frac{1}{3072}$ part of the whole circumference, is alſo known.
That is $Ad^{ix} = (\sqrt{\overline{AF}^2 - \overline{Fd^{ix}}^2} =)\ \sqrt{4 - \overline{2 + Fd^{viii}}} = 0{,}00204530736 06764$

268. Conſequently, the ſide of a regular polygon of 3072 ſides inſcribed in a circle whoſe diameter is 2, is 0,00204530736 06764



269. *The ſide of a ſimilar polygon circumſcribing the ſame circle, whoſe centre is* C, *may be thus found.*

Let BE be the ſide of the circumſcribed polygon; and draw BC, EC, cutting the circle in D and A.

Draw DA, and it will be the ſide of the inſcribed polygon; and is parallel to BE. (258)

Draw CI biſecting the angle BCE, and it will biſect BE and DA at right angles (193). And $\text{DG} = (\frac{1}{2}\text{DA} =)\ \frac{1}{2}\text{A}d^{\text{ix}}$.

Then $\text{CG} = \sqrt{\overline{\text{CD}}^2 - \overline{\text{DG}}^2} = \sqrt{1 - \overline{\frac{1}{2}\text{A}d^{\text{ix}}}^2}$.

But $\frac{1}{2}\text{A}d^{\text{ix}} = 0{,}001022653680338$. And its ſquare is 0,00000104582055

Which ſubtracted from 1 leaves 0,99999895417945

Whoſe ſquare root, or CG, is equal to 0,99999947708959

Now the triangles CBI, CDG, are ſimilar.

Then CG : CI :: 2DG : 2BI. (250, 234)

Therefore $(2\text{BI} =)\ \text{BE} = (\frac{2\text{DG} \times \text{CI}}{\text{CG}}\ (247) =)\ \frac{\text{DA}}{\text{CG}}$; For IC = 1.

Or $\text{BE} = (\frac{0{,}0020453073606764}{0{,}9999994770895883} =)$ 0,0020453084301895

which is the ſide of a regular polygon of 3072 ſides circumſcribing a circle whoſe diameter is 2.

270. SCHOLIUM. The ſide of a regular polygon of 3072 ſides, inſcribed in a circle whoſe diameter is 2, is 0,0020453073606764. (268)

Which multiplied by 3072, will give the perimeter of that polygon, which is 6,2831842119979622.

The ſide of a ſimilar polygon, circumſcribing the ſame circle is 0,0020453084301895. (269)

Which multiplied by 3072, will give for the perimeter of that polygon 6,2831874973420925.

The ſum of theſe perimeters is 12,5663717093400547.

The half ſum is 6,28318585 &c.

Which is very nearly equal to the circumference of a circle whoſe diameter is 2 (261), the difference between it

and the inſcribed polygon being only 0,00000164 &c.

and the circumſcribed polygon being only 0,00000164 &c.

271. Now the circumferences of circles being in the ſame proportion, as their diameters. (262)

Therefore the diameter of a circle being 1,

The circumference will be 3,141592 &c. which agrees with the circumference as found by other methods.

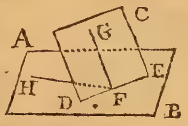
SECTION V.

OF PLANES AND SOLIDS.

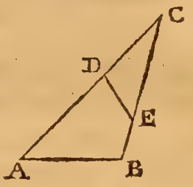
Definitions and Principles.

272. A line is ſaid to be in a plane, when it paſſes thro' two or more points in that plane.

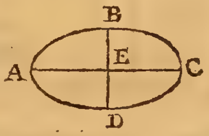
273. The inclination of two meeting planes (AB), (CD), is meaſured by an acute angle (GFH), made by two right lines (FG, FH), one in each plane, and both drawn perpendicular to their common ſection (DE), from (F) ſome point therein.



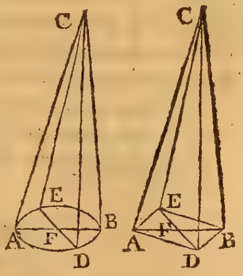
274. A right line (DE) interſecting two ſides (AC, BC), of a triangle (ABC), ſo as to make angles (CDE, CED), within the figure, equal to the angles (CBA, CAB) at the baſe (AB), but with contrary ſides of the triangle, is ſaid to be in a ſubcontrary poſition to the baſe.



275. If a circle in an oblique poſition be viewed, it will appear of an oval form (as ABCD); that is, it will ſeem to be longer one way (as AC) than another (as DB); nevertheleſs the radius's (EA, EB) are to be eſteemed as equal: And the ſame muſt be underſtood in viewing of any regular figure when placed obliquely to the eye.



276. If a line be fixed to any point (C) above the plane of a circle (ADBE), and this line while ſtretched be moved round the circle, ſo as always to touch it; then a ſolid which would fill the ſpace paſſed over by the line, between the circle and the point C, is called a CONE.



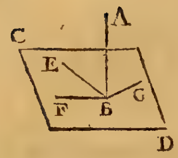
277. If the figure ADBE had been a polygon, and the ſtretched line had moved along its ſides, the figure which would then have been deſcribed, is called a PYRAMID.

So that Cones and Pyramids are ſolids which regularly taper from a circle, or polygon, to a point.

The circle or polygon is called the *Baſe*; and the point C the *Vertex*.

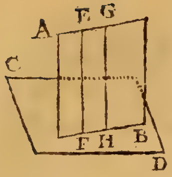
When the vertex is perpendicularly over the middle or centre of the baſe, then the ſolid is called a RIGHT CONE, or a RIGHT PYRAMID; otherwiſe, an OBLIQUE CONE, or OBLIQUE PYRAMID.

278. If a Cone or Pyramid be cut by a plane paſſing thro' the vertex C, and centre of the baſe F, the ſection ABC, or EDC, is a triangle,



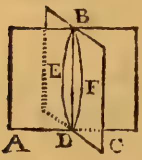
279. A right line (AB) is perpendicular to a plane (CD) when it makes right angles (ABE, ABF, ABG) with all the right lines (BE, BF, BG) drawn in that plane to touch the ſaid right line (AB).

280. So that from the ſame point (B) in a plane, only one perpendicular can be drawn to that plane, on the ſame ſide.



281. A plane (AB) is perpendicular to a plane (CD), when the right lines (EF, GH) drawn in one plane (AB) at right angles to (FB), the common ſection of the two planes, is alſo at right angles to the other plane (CD).

282. So that a line (EF) perpendicular to a plane (CD), is in another plane (AB), and at right angles to (FB) the ſection of the two planes.



283. THEOREM XXXII.

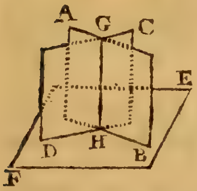
If two planes (AB, CB) *cut each other, their common ſection* (BD) *will be a right line.*

DEM. For if it be not, draw a right line DEB in the plane AB, from the point D to the point B; alſo draw a right line DFB in the plane BC.

Then two right lines DEB, DFB, have the ſame terms, and include a ſpace or figure which is abſurd. (98)

Therefore DEB and DFB are not right lines: Neither can any other lines drawn from D to B, beſides BD, be right lines.

Conſequently the line DB the ſection of the planes, is a right line.



284. THEOREM XXXIII.

If two planes (AB, CD), *which are both perpendicular to a third plane* (EF), *do cut one another; their interſection* (HG) *is at right angles to that third plane* (EF).

DEM. For the common ſection of AB and CD is a right line (GH) (283): Alſo HB, HD, are the ſections of AB, CD, with the plane EF.

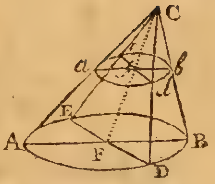
Now from the point H, a line HG drawn perpendicular to the plane EF, muſt be at right angles to HB, HD. (279)

But HG muſt be in both planes AB, CD. (282)

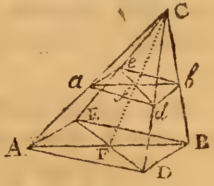
Therefore it muſt be in the ſections of thoſe planes.

Conſequently the ſection HG of the planes AB, CD, is at right angles to the plane EF.

285. THEOREM XXXIV.



The ſections (a e b d) of a Cone or Pyramid (CAEBD), *which are parallel to the baſe* (AEBD), *are ſimilar to that baſe.*



DEM. For let AFBC, DFEC, be ſections thro' the vertex C, and centre F of the baſe.

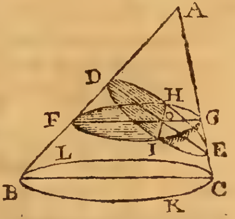
Then theſe ſections will cut one another in the right line FC (283), and the tranſverſe ſection *a d b e* in the right lines *a b*, and *e d*, interſecting in *f*.

Then are the following ſets of triangles, ſimilar: namely AFC, *a f* C; BFC, *b f* C; DFC, *d f* C; EFC, *e f* C.

Wherefore FC : *f* C :: FA : *f a*
:: FB : *f b*
:: FD : *f d*
:: FE : *f e*
And the like in any other ſections thro' C and F. (248)

Now in the Cone, FA=FB=FD=FE; therefore *fa*=*fb*=*fd*=*fe*. (241)
So that all the right lines drawn from *f* to the circumference of the figure *a d b e* are equal to one another.
Conſequently the figure *a d b e* is a circle. (100)
And in the Pyramid, FC : *f* C :: DC : *d* C :: DB : *d b* :: DA : *d a*.
FC : *f* C :: EC : *e* C :: EA : *e a* :: EB : *e b*.
Therefore in each pair of correſponding triangles in the baſe and tranſverſe ſection, the ſides are reſpectively proportional.
Conſequently, as the baſe and tranſverſe ſection are compoſed of like ſets of ſimilar triangles; therefore they are alſo ſimilar. (257)

286. THEOREM XXXV.



If a Cone (ABLCK) *whoſe baſe is a circle* (BLCK), *be cut by a plane in a ſubcontrary poſition to the baſe, the ſection* (DIEH) *will be a circle.*

DEM. Thro' the vertex A, and centre of the baſe, let the triangular ſection ABC be taken ſo as to be at right angles to the planes of the baſe BKCL, of the ſubcontrary ſection DIEH, and of the ſection FIGH taken parallel to the baſe and cutting the ſubcontrary ſection in the line IOH.
Therefore IOH is perpendicular to DE and FG (284) cutting one another in O.
Now the ſection FIGH is a circle (285). Therefore FO × OG = $\overline{OI}^2$ (254).
Again. The triangles GOE, FOD, are ſimilar.
For ∠ GEO = ∠ DFO = ∠ ABC by conſtr. And ∠ GOE = ∠ DOF. (183)
Therefore EO : OG :: FO : DO (250). And EO × DO = FO × OG (255) = $\overline{OI}^2$
So that OI is a mean proportional, either between FO & OG, or DO & EO.
But as the ſame would happen wherever FG cuts DE; therefore all the lines OI, both in the ſections FIGH & DIEH, are lines in a circle.
Conſequently the ſection DIEH is a circle.

SECTION VI.

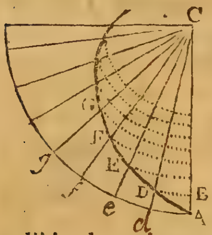
OF THE SPIRAL.

287. *Suppoſe the radius of a circle to revolve with an uniform motion round its centre, and while it is revolving, a point is moving along the radius; then will the ſucceſſive places of that point be in a curve which is called a ſpiral.*

This will be readily conceived by imagining a fly to run along the ſpoke of a wheel, while the wheel is turning round.

If while the radius revolves once, the point has moved the length of the radius; then the ſpiral will have revolved but once round the centre, or pole; conſequently the motion in the circumference is to the motion in the radius, as the circumference is to the radius: And if the wheel revolves twice, thrice, or in any proportion to the motion in the radius; then the ſpiral will make ſo many turns, or parts of a turn, round the centre.

288. *Now ſuppoſe while the radius revolves equably, if a point from the circumference moves towards the centre, with a motion decreaſing in a geometric progreſſion; then will a ſpiral be generated which is called a proportional ſpiral.*



Let the radius CA be divided in any continued decreaſing geometric progreſſion, as of 10 to 8; then the ſeries of terms will be 10; 8; 6,4; 5,12; 4,096; 3,2768; 2,62144 &c. Alſo let the circumference be divided into any number of equal parts, in the points *d*, *e*, *f*, *g*, &c. Then if the ſeveral diviſions of the radius CA, be ſucceſſively transferred from the centre C, cutting the other radii in the points D, E, F, G, &c. and a curved line be evenly drawn thro' thoſe points, it will be a ſpiral of the kind propoſed.

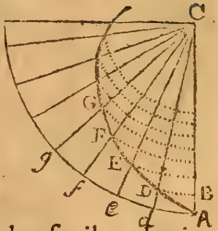
289. From the nature of a decreaſing geometric progreſſion, it is eaſy to conceive that the radius CA may be continually divided; and altho' each ſucceſſive diviſion becomes ſhorter than the next preceding one, yet there muſt be an indefinite number of diviſions, or terms, before the laſt of them becomes of no finite magnitude.

290. Hence it follows, that this ſpiral winds continually round the centre, and does not fall into it till after an indefinite number of revolutions.

Alſo, that the number of revolutions decreaſe, as the number of the equal parts into which the circumference is divided, increaſes.

291. THEOREM XXXVI.

Any proportional ſpiral cuts the intercepted radii at equal angles.



Dem. If the diviſions A d, de, ef, fg, *&c.* of the circumference were very ſmall, then would the ſeveral radii be ſo cloſe to one another, that the intercepted parts AD, DE, EF, FG, *&c.* of the ſpiral might be taken as right lines.

And the triangles CAD, CDE, CEF, *&c.* would be ſimilar, having equal angles at the point C, and the ſides about thoſe angles proportional. (251)

Therefore the angles at A, D, E, F, *&c.* being equal, the ſpiral muſt neceſſarily cut the radii at equal angles.

292. THEOREM XXXVII.

If the radii of any proportional ſpiral be taken as numbers, then will the correſponding arcs of the circle, reckoned from their commencement, be as the logarithms of thoſe numbers.

Dem. As the lines CA, CD, CE, CF, CG, *&c.* are a ſeries of terms in geometric progreſſion; and the arcs A d, A e, A f, A g, *&c.* are a ſeries of terms in arithmetic progreſſion; therefore theſe arcs may ſerve (70) as the indices to the geometric terms, and be thus placed;

Radii of the ſpiral CA, CD, CE, CF, CG, *&c.* Geometric terms.
Correſponding arcs 0, A d, A e, A f, A g, *&c.* Arith. terms or indices.

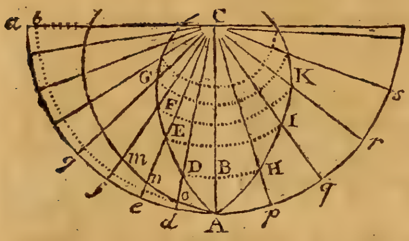
In this diſpoſition, the firſt term CA, is not diſtant from itſelf, therefore its index is repreſented by 0.

Then if the diſtance of the ſecond term CD from the firſt term CA be expreſſed by the arc A d; the diſtance of the third term CE, from CA, will be expreſſed by the arc A e; and ſo of the reſt.

Conſequently, if the terms in the geometric ſeries be repreſented by numbers, taken as parts of the radius, then the numbers, of the ſame kind, expreſſing the meaſures of the arcs, or indices, will be as the logarithms of the geometric terms. (73)

293. Corol. If the difference between CA and CB was indefinitely ſmall, or CA and CB were nearly in a ratio of equality; then might the number of proportional lines into which CA could be divided, be ſo many, that any propoſed number might be found among the terms of this ſeries; and if the number of parts in the circumference was increaſed in like manner, then would every term of the proportional diviſion of the radius CA, have its correſponding index among the equal diviſions of the circumference; and conſequently would exhibit the logarithms of all numbers.

294. THEOREM XXXVIII.



There may be an almoſt infinite variety of proportional ſpirals, and as many different kinds of logarithms.

Dem. For with the ſame equal diviſions A *d*, *de*, *ef*, *&c.* of the circumference, every variation in the ratio of CA to CB, as of C*a* to C*b*, will produce a different ſpiral A *o n m*.

And with the ſame diviſions of the radius CA, and different ſets of equal parts A*d*, *de*, *ef*, *&c.* and A*p*, *pq*, *qr*, *&c.* of the circumference, may be formed different ſpirals ADEF, AHIK.

Alſo varying at the ſame time, both the diviſions of the radius and circumference, different ſpirals will be produced.

But the variations in theſe three caſes may be almoſt infinite: Therefore the number of ſuch ſpirals are almoſt infinite.

Now it is evident that there is a peculiar relation between the rays of any ſpiral, and the correſponding arcs of the circle; that is, between the terms of a geometric progreſſion and its indices: Therefore there may be as many kinds of logarithms as there are proportional ſpirals.

295. THEOREM XXXIX.

That proportional ſpiral which interſects equidiſtant rays at an angle of 45 *degrees, produces logarithms that are of* Nepier*'s kind.*

Dem. Suppoſe AB, the difference between CA and CB, the firſt and ſecond terms of the geometric progreſſion, to be indefinitely ſmall, and take A*p*, the logarithm of CB, equal to AB; then may the figure ABH*p* be taken as a ſquare, whoſe diagonal AH would be part of the ſpiral AHIK, and the angle BAH would be half a right one, or 45 degrees.

Therefore that ſpiral which cuts its rays CA, CH, *&c.* at angles of 45 degrees, has a kind of logarithms belonging to it, ſo related to their correſponding numbers, that the ſmalleſt variation between the firſt and ſecond numbers, is equal to the logarithm of the ſecond number.

But of this kind were the firſt logarithms made by Lord *Nepier.*

Therefore the logarithms to the ſpiral which cuts its equidiſtant rays at an angle of 45 degrees, are of the *Nepierian* kind.

THE ELEMENTS OF NAVIGATION.

BOOK III.

OF PLANE TRIGONOMETRY.

SECTION I.

Definitions and *Principles.*

296. PLANE TRIGONOMETRY is an art which ſhews how to find the meaſures of the ſides and angles of plane Triangles, ſome of them being already known.

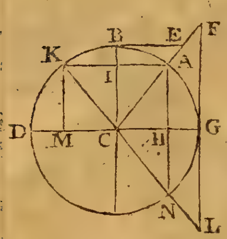
It will be proper for the learner, before he reads the following Articles, to turn to the definitions relative to a circle and angle, contained in the Articles 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, and 127.

297. A Triangle conſiſts of ſix parts; namely, three ſides and three angles.

The ſides of plane triangles are denoted or eſtimated by meaſures of length; ſuch as Feet, Yards, Fathoms, Furlongs, Miles, Leagues, *&c.*

The angles of triangles are eſtimated by circular meaſure, that is, by arcs containing Degrees, Minutes, Seconds, *&c.* (106); and for convenience theſe circular meaſures are repreſented by right lines, called right ſines, tangents, ſecants, and verſed ſines.

298. The Right Sine of an arc, or angle, is a right line drawn from one end of the arc perpendicular to a radius drawn to the other end: Or it is half the chord of the double of that arc.



Thus AH is the right ſine of the arc AG; and alſo of the arc DBA.

299. The Tangent of an arc, is a right line touching one end of the arc, and continued till it meets a right line drawn from the centre thro' the other end of that arc.
Thus GF is the tangent of the arc GA.

300. The Secant of an arc, is a right line drawn from the centre thro' one end of the arc, and produced till it meets the tangent drawn from the other end.
Thus CF is the ſecant of the arc AG.

301. The Versed Sine of an arc, is that part of the radius intercepted between the arc and its right ſine.
Thus HG is the verſed ſine of the arc AG.

302. The Complement of an arc, is what that arc wants of 90 degrees.
Thus if the arc GB = 90°. Then AB is called the complement of AG; and AG is the complement of AB.

303. The Supplement of an arc, is what that arc wants of 180 degrees.
Thus the arc ABD is the ſupplement of AG; and AG of ABD.

304. The Co-sine, Co-tangent, Co-secant, Co-versed Sine of an arc, is the right ſine, tangent, ſecant, verſed ſine of the complement of that arc.
Thus AI, BE, CE, BI, being reſpectively the ſine, tangent, ſecant and verſed ſine of the arc AB, which is the complement of AG; therefore AI is called the co-ſine, BE the co-tangent, CE the co-ſecant, BI the co-verſed ſine of the arc AG.

AXIOMS.

AXIOMS.

305. The greateſt right ſine, is the ſine of 90°; and the ſines to arcs leſs than 90°, ſerve equally for arcs as much greater than 90°.

Thus the ſines of 80° and 100°; of 60° and 120°; of 40° and 140° *&c.* are reſpectively equal.

306. The ſame tangent and ſecant will ſerve to arcs equally diſtant from 90 degrees; that is, to any arc and its ſupplement.

Thus if the arc BAG = 90°, and BK = BA; then KM, GL, CL, the ſine, tangent, ſecant of the arc GBK, are reſpectively equal to AH, GF, CF, the ſine, tangent, ſecant of the arc GA = DK, the ſupplement of the arc GBK.

307. When an arc is greater than 90°; the ſine, tangent, ſecant, of the ſupplement is to be uſed.

308. The chord (AN) of an arc (AGN), is equal to twice (CI) the coſine of (AB) half the ſupplemental arc (ABK).

309. The verſed ſine and co-ſine together (HG + CH) of any arc (AG), is equal to the radius, CH being equal to AI.

310. The ſines, tangents, ſecants, or verſed ſines, of ſimilar arcs in different circles, are in the ſame proportion to one another as the radii of thoſe circles. (259)

311. The angles of two triangles may be reſpectively equal, altho' their ſides may be unequal.

Therefore in a triangle among the things given, in order to find the reſt, one of them muſt be a ſide.

In Trigonometry, the three things given in a triangle muſt be either

1ſt. Two ſides and an angle oppoſite to one of them.

2d. Two angles and a ſide oppoſite to one of them.

3d. Two ſides and the included angle.

4th. The three ſides.

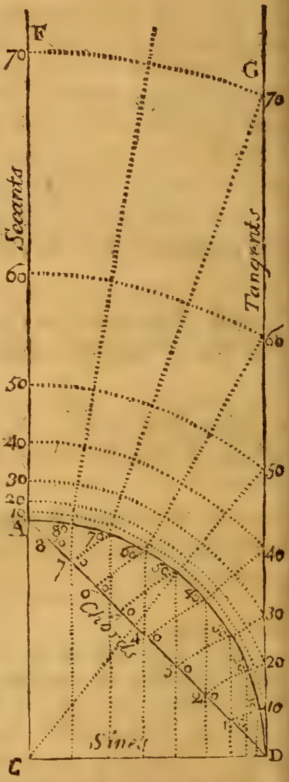
In either caſe, the other three things may be found by the help of a few Theorems, and a *Triangular Canon*, which is a Table wherein are orderly inſerted every degree and minute in a quadrant or arc of 90° degrees; and againſt them, the meaſures of the lengths of their correſponding ſines, tangents and ſecants, eſtimated in parts of the Radius, which is uſually ſuppoſed to be divided into a number of equal parts, as 10, 100, 1000, 10000, 100000, *&c.*

SECTION II.

Of the Triangular Canon.

PROPOSITION I.

312. *To find the lengths of the Chords, Sines, Tangents and Secants to arcs of a circle of a given radius.*



Construction. Thro' each end of the given radius CD, and at right angles to it (149) draw the lines CF, DG: On C with the radius CD, deſcribe the quadrantal arc DA, and draw the chord DA.

313. For the Chords. Triſect the arc AD (152), and (by trials) triſect each part; then the arc AD will be divided into 9 equal parts of 10 degrees each; if theſe arcs are divided each into 10 equal parts, the quadrant will be divided into 90 degrees: But in this ſmall figure, the diviſions to every 10 degrees only, are retained, as in art. 174.

From D as a centre, with the radius to each diviſion, cut the right line DA; and it will contain the chords of the ſeveral arcs into which the quadrantal arc AD was divided.

For the diſtances from D to the ſeveral diviſions of the right line DA, are hereby made reſpectively equal to the diſtances or cords of the ſeveral arcs reckoned from D.

314. For the Sines. Thro' each of the diviſions of the arc AD, draw right lines parallel to the radius AC; theſe parallel lines will be the right ſines of their reſpective arcs, and CD will be divided into a line of ſines, which are to be numbered from C to D, for the right ſines; and from D to C for the verſed ſines.

For the diſtances from C to the ſeveral diviſions of the right line CD, are reſpectively equal to the ſines of the ſeveral arcs beginning from A.

315. For the Tangents. A ruler on C, and the ſeveral diviſions of the arc AD, will interſect the line DG; and the diſtances from D to the ſeveral diviſions of DG will be the lengths of the ſeveral tangents.

316. For the Secants. From the centre C, with radii to the diviſions of the tangent DG, cut the line CF; and the diſtances from C to the ſeveral diviſions of CF, will be the lengths of the ſecants to the ſeveral arcs.

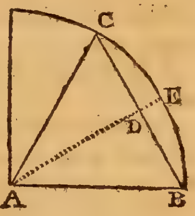
For theſe lengths are made reſpectively equal to the ſecants reckoned from C to the ſeveral diviſions of the tangent DG.

317. If the figure was ſo large that the quadrantal arc could contain every degree and minute of the quadrant, or 5400 equal parts; then the chord, ſine, tangent and ſecant to each of them could be drawn. Now a ſcale of equal parts being conſtructed, 1000 of which parts are equal to the radius CD; then the lengths of the ſeveral ſines, tangents aud ſecants may be meaſured from that ſcale, and entered in a table called the triangular canon, or the table of ſines, tangents and ſecants.

But as theſe meaſures cannot be taken with ſufficient accuracy to ſerve for the computations to which ſuch tables are applicable; therefore the ſeveral lengths have been calculated for a radius divided into a much greater number of equal parts; as is ſhewn in the following articles.

318. PROP. II.

In any circle, the chord of 60 *degrees, is equal to the radius: and the ſine of* 30 *degrees, is equal to half the radius.*



DEM. Let the arc CB, or $\angle$ CAB $=$ 60 degrees; and draw the chord CB.

Now ſince the radii AC and AB are equal; (100)

Therefore $\angle$ C $= \angle$ B. (194)

And the $\angle$C $+ \angle$B $=$ (180° − ($\angle$ A $=$) 60° $=$) 120° (186)

Therefore $\angle$ C, or $\angle$B $=$ (half 120°; or $=$) 60° $= \angle$ A.

Conſequently CB $=$ AB $=$ AC.

From A, draw the radius AE perpendicular to CB.

Then AE biſects the arc CB, and its chord. (207)

And CD $=$ ſine of (the arc CE $=$ half of 60° $=$) 30°. (298)

Conſequently CD is equal to half the radius AB.

319. Hence, *Twice the co-ſine of* 60 *degrees is equal to the radius.* For 30° is the complement of 60°; and twice the ſine of 30 is equal to the radius.

320. PROP. III.

To find the ſine of one minute of a degree.

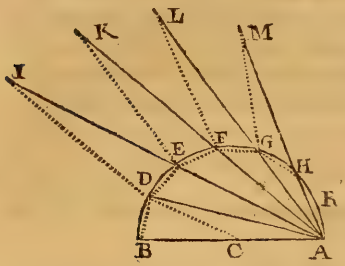
It is evident (261), that the leſs the arc is, the leſs is the difference between the arc and its ſine, or half chord; ſo that a very ſmall arc, ſuch as that of one minute, may be reckoned to differ from its ſine, by ſo ſmall a quantity, that they may be eſteemed as equal; and conſequently may be expreſſed by the ſame number of ſuch equal parts of which the radius is ſuppoſed to contain 1,00000 &c. which is readily found by the following proportion.

As the circumf. of the circle in minutes	21600
To the circumf. in equal parts of the radius (270)	6,283185
So is the arc of one minute	1,
To the correſponding parts of the radius	0,0002908882
So that for the ſine of one minute, may be taken	0,0002908882

321.

321. PROP. IV.

In a ſeries of arcs in arithmetic progreſſion, the ſine of any one of them taken as a mean, and the ſum of the ſines of any other two, taken as equidiſtant extremes, are ever in a conſtant ratio, of radius to twice the co-ſine of the common difference of thoſe arcs.



DEM. For in a circumference whoſe centre is C, and diameter AB, let there be taken a ſeries of arcs, ARB, ARD, ARE, ARF, ARG, ARH, &c. whoſe common difference is the arc BD.

Then drawing the chords AB, AD, AE, AF, AG, AH, &c. their halves will be the ſines of half the arcs ARB, ARD, &c. (298)

Alſo half the arc BD, is the common difference of half the arcs ARB, ARD, ARE, &c. (233)

And the chord AD is twice the co-ſine of half the ſupplemental arc BD. (308)

From the points D, E, F, G, &c. with the radii DA, EA, FA, GA, &c. cut AE, AF, AG, AH, &c. produced, in I, K, L, M, &c. draw ID, KE, LF, MG, &c. and BD, DE, EF, FG, GH, &c.

Then by the firſt part of the demonſtration to art. 263, the following triangles are congruous, namely,

ABD, IED; ADE, KFE; AEF, LGF; AFG, MHG, &c.

Therefore $IE = AB$; $KF = AD$; $LG = AE$; $MH = AF$, &c.

Alſo, the triangles IDA, KEA, LFA, MGA, &c. being each of them Iſoſceles, and their angles reſpectively equal, are ſimilar to DCA. (250)

$$
\begin{aligned}
\text{Therefore } CA : AD &:: (AD : (AI =)\ AB + AE ::)\ \tfrac{1}{2} AD : \tfrac{1}{2} AB + \tfrac{1}{2} AE. \\
&:: (AE : (AK =)\ AD + AF ::)\ \tfrac{1}{2} AE : \tfrac{1}{2} AD + \tfrac{1}{2} AF. \\
&:: (AF : (AL =)\ AE + AG ::)\ \tfrac{1}{2} AF : \tfrac{1}{2} AE + \tfrac{1}{2} AG. \\
&\quad \&c. \qquad\qquad\qquad\qquad \&c.
\end{aligned}
$$

The halves being in the ſame ratio as the wholes. (233)

322. Conſequently, In a ſeries of arcs in arithmetic progreſſion, *viz.* $\frac{1}{2}$ ARB, $\frac{1}{2}$ ARD, $\frac{1}{2}$ ARE, &c. whoſe common difference is half the arc BD, it will be,

As (AC) Radius,
To (AD) twice the co-ſine of the common difference;
So is the ſine of either arc taken as a mean,
To the ſum of the ſines of two equidiſtant extremes.

323. Hence; *The ſine of either extreme, ſubtracted from the product of the ſine of the mean by twice the co-ſine of the common difference, will give the ſine of the other extreme.* (247)

324. When the common difference of the arcs is 60 degrees; then twice the co-ſine of its complement is equal to the radius. (319)

$$\left.\begin{array}{l} \text{And (322) R} : (2\,\text{coſ}.\,60^\circ =)\ \text{R} :: \text{s}, 90^\circ : (\text{s}, 30^\circ + \text{s}, 150^\circ =)\ \text{s}, 30^\circ + \text{s}, 30^\circ. \\ \qquad\qquad\qquad\qquad\qquad :: \text{s}, 85\ : (\text{s}, 25^\circ + \text{s}, 145^\circ =)\ \text{s}, 25^\circ + \text{s}, 35^\circ. \\ \qquad\qquad\qquad\qquad\qquad :: \text{s}, 80\ : (\text{s}, 20^\circ + \text{s}, 140^\circ =)\ \text{s}, 20^\circ + \text{s}, 40^\circ. \\ \qquad\qquad\qquad\qquad\qquad :: \text{s}, 75\ : (\text{s}, 15^\circ + \text{s}, 135^\circ =)\ \text{s}, 15^\circ + \text{s}, 45^\circ. \\ \qquad\qquad\qquad\qquad\qquad\quad \&c. \qquad\qquad\qquad\qquad\qquad \&c. \end{array}\right\}(305)$$

Here the firſt and ſecond terms in the proportions being equal, the third and fourth terms are alſo equal.

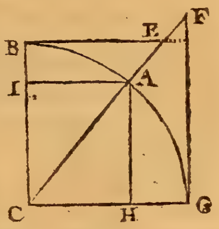
325. Hence, *The ſine of an arc greater than* 60 *degrees, is equal to the ſine of an arc as much leſs than* 60 *degrees, added to the ſine of its difference from* 60 *degrees.*

Therefore the ſines of arcs above 60 degrees, are readily obtained from thoſe under 60 degrees.

326. PROP. V.

The right ſine of an arc being known, to find its co-ſine; and from theſe, to find the tangent, ſecant, verſed ſine; and alſo the co-tangent, co-ſecant, and co-verſed ſine.

Let AG be any arc, and let AH be its ſine, AI its co-ſine; GF the tangent, BE the co-tangent; CF the ſecant, CE the co-ſecant; HG the verſed ſine, BI the co-verſed ſine.



Now if the ſine AH be given, then the co-ſine AI or CH, will be known (203): For $\overline{CA}^2 - \overline{AH}^2 = \overline{CH}^2$. Therefore *the ſquare root of the difference between the ſquares of the radius and ſine, will be the co-ſine.*

327. Then the verſed ſine HG = CG − CH; and co-verſed ſine IB = CB − CI.
And ſince the triangles CHA, CGF, CBE, are ſimilar,

328. Therefore (250) CH : HA : : CG : GF the tangent.
That is, *As the co-ſine to the ſine, ſo is radius to the tangent.*

329. And CH : CA : : CG : CF the ſecant.
That is, *As the co-ſine to the radius, ſo is the radius to the ſecant.*

330. And CI : CA : : CB : CE the co-ſecant.
That is, *As the ſine to radius, ſo is radius to the co-ſecant.*

331. Alſo CI : IA : : CB : BE, the co-tangent.
That is, *As the ſine to the co-ſine, ſo is radius to the co-tangent.*
Or GF : CG : : CB : BE; that is, *As tangent* : *rad* : : *rad* : *co-tangent.*

332. Hence it is evident, that *the tangent and co-tangent of an arc of* 45° *are equal to one another, and to the radius, or ſine of* 90 *degrees.*

And as the ſquare of radius is equal to the rectangle of any tangent and its co-tangent,

Therefore tan. × cot. = *tan.* × *cot.* Therefore tan. : *tan.* : : *cot.* : cot. (246)

Or the tangents of different arcs are reciprocally as their co-tangents.

333. The principles by which the lengths of the ſines, tangents, ſecants, &c. may be conſtructed, being delivered, the following examples are annexed to illuſtrate this doctrine.

Required the co-ſine of one minute.

The ſine of 1 minute being	0,0002908882 (320)
Its ſquare is	0,00000008461594
Which ſubtracted from the ſquare of radius	1,
Leaves	0,99999991538406
Whoſe ſquare root	0,9999999577 is the

co-ſine of 1 minute; or the ſine of 89°. 59′.

Now having the ſine and co-ſine of 1 minute, the other ſines may be found in the following manner. (323)

twice the coſ. 1 min. × ſine of 1 m. = ſum of the ſines of 0′ & 2′.
twice the coſ. 1 min. × ſine of 2 m. = ſum of the ſines of 1′ & 3′.
twice the coſ. 1 min. × ſine of 3 m. = ſum of the ſines of 2′ & 4′.
twice the coſ. 1 min. × ſine of 4 m. = ſum of the ſines of 3′ & 5′.
twice the coſ. 1 min. × ſine of 5 m. = ſum of the ſines of 4′ & 6′.

Proceeding thus in a progreſſive order from each ſine to its next, all the ſines may be found.

But as twice the co-ſine of 1 minute, *viz.* 1,9999999154 is concerned in each operation, therefore if a table be made of the products of this number by the nine digits, as here annexed, the computations of the ſines may be performed by addition only.

For the products by the digits in the given multiplier, being taken from the table, and wrote in their proper order, will prevent the trouble of multiplication.

And even this operation may be very much ſhortened, by ſetting under the right hand place (*viz.* 4) of the double co-ſine of one minute, the unit place of the ſine uſed as a multiplier; and reverſing, or placing in a contrary order, all its other figures; then the right hand figure of each line ariſing by the multiplication, is to be ſet under one another; and in theſe lines, the firſt figure to be ſet down, is what ariſes from the figure ſtanding over the preſent multiplying one; obſerving to add what would be carried from the places omitted.

Multipliers.	Products.
1	1,9999999154
2	3,9999998308
3	5,9999997462
4	7,9999996616
5	9,9999995770
6	11,9999994924
7	13,9999994078
8	15,9999993232
9	17,9999992386

Now if the products of the figures in the multiplier, thus inverted, be taken from the table of products; it is neceſſary to remark what number of places will ariſe from each digit uſed in the multiplier; then in the products of thoſe digits in the table, take only the like number of places, obſerving to add 1 to the right hand place, if the next of the omitted figures exceed 5.

Required the ſine of 2 minutes.

The ſine of 1 min. placed in an inverted order under the double coſ. of 1 min. as in the margin; the right hand figure 2 ſtands under the 9 in the 6th decimal place, therefore the firſt 6 decimal places of the product againſt 2 in the table, are to be uſed; but 1 being added, becauſe the 7th place 8, exceeds 5, makes the product 4000000: Alſo, for 9 the next figure in the multiplier, ſtanding under the 5th decimal place, take 17,99999 from the table of products, and 1 being added to the 5th place, becauſe the 6th exceeds 5, makes it 18,00000: In like manner, the product by 8, adding 1, is 16000 &c. and the ſum of theſe products 0,0005817764 is the the ſine of 2 min. as required.

1,9999999154
2888092000,0
4000000
1800000
16000
1600
160
4
0,0005817764

This kind of operation will be very eaſily conceived, without farther illuſtration, by comparing the proceſs in this and the following operations, with what has been already ſaid.

Required the ſines of 3′, 4′, 5′, & 6 *minutes.*

For 3 min.	For 4 min.	For 5 min.	For 6 min.
1,9999999154	1,9999999154	1,9999999154	1,9999999154
4677185000,0	5466278000,0	6255361100,0	5044454100,0
9999999	16000000	19999999	19999999
1600000	1400000	2000000	8000000
20000	40000	1200000	1000000
14000	12000	60000	80000
1400	1200	10000	8000
120	80	1000	800
8	10	40	10
		12	
0,0011635527	0,0017453290	0,0023271051	0,0029088809
0,0002908882	0,0005817764	0,0008726645	0,0011635526
0,0008726645	0,0011635526	0,0014544406	0,0017453283

In each example, the ſine of 2 min. leſs, (323) is ſubtracted.

The ſines being made, the tangents, ſecants, &c. are to be conſtructed as before ſhewn. (327, 328)

334. There are many methods by which the triangular canon may be made; but that which is here delivered was choſen as the moſt eaſy, the beſt adapted to this work, and what would give the learner a ſufficient notion how theſe numbers are to be found: For at this time, there is no occaſion to conſtruct new tables of ſines, and rarely to examine thoſe already extant; they having paſſed thro' the hands of a great many careful examiners, and for a long time have been received by the learned as a work ſufficiently correct.

Theſe lines were firſt introduced into mathematical computations by *Hipparchus* and *Menelaus*, whoſe methods of performance were contracted by *Ptolomy*, and afterwards perfected by *Regiomontanus*; and ſince his time *Rheticus*, *Clavius*, *Petiſcus*, and many other eminent men, have treated largely on this ſubject, and greatly exemplified the uſe of this triangular Canon, or Tables; which are now, by way of diſtinction, called Tables of *natural* ſines, tangents, &c. But the greateſt improvement ever made in this kind of mathematical learning, was by the Lord *Napier*, Baron of *Merchiſton* in *Scotland*; who being very fond of ſuch ſtudies, wherein calculations by the ſines, tangents, &c. did frequently occur, judged it would be of vaſt advantage could theſe long multiplications and diviſions be avoided; and this he effected by his happy invention of computing by certain numbers conſidered as the indices of others (73), which he called logarithms; this was about the year 1614.

The tables now chiefly uſed in Trigonometrical computations, are the logarithms of thoſe numbers which expreſs the lengths of the ſines, tangents, &c. and therefore to diſtinguiſh them from the *natural* ones, they are called *Logarithmic* ſines, tangents, &c. (or by ſome artificial ſines, &c.) Only thoſe of the logarithmic ſines and tangents are annexed to this treatiſe, becauſe the buſineſs of Navigation may be performed by them; neither are theſe tables carried to more than five places beſide the index, that being ſufficiently exact for all nautical purpoſes: But it muſt be allowed that, for general uſe, ſuch tables are the moſt eſteemed, as conſiſt of moſt places.

335. Theſe tables are ſo diſpoſed, that each opening of the book contains ſix degrees; three of which are numbered at top, and three at the bottom of the page; thoſe at top proceed from left to right, or forwards, from 0 degrees to 45; and thoſe at bottom, from right to left, or backwards, from 45 to 90 degrees: To each degree there are four columns, titled ſines, tangents, co-ſines, co-tangents; and the minutes are in the marginal column of each page, ſigned with M; thoſe on the left ſide belong to the degrees at top, and thoſe on the right hand ſide of the page, to the degrees at bottom.

336. Now a ſine, tangent, co-ſine, co-tangent, to a given number of degrees, is found as follows.

For an arc leſs than 45 degrees.

Seek the degree at top, and the minutes in the column ſigned M at top; againſt which, in the column ſigned at top with the propoſed name, ſtands the ſine, or tangent &c. required.

But when the arc is greater than 45 degrees,

Seek the degree at bottom, the min. in the column with M at bottom, and the propoſed name at bottom.

EXAMPLE I. *Required the logarithmic ſine of* 28°. 37′.

Find 28 deg. at the top of the page; and in the ſide column marked with M at top, find 37; againſt which, in the column ſigned at top with the word ſine, ſtands 9,68029, the log. ſine of 28°. 37′. as required.

EXAMPLE II. *Required the logarithmic tangent of* 67°. 45′.

Find 67 deg. at the bottom of the page; and in the ſide column titled M at the bottom, find 45; then againſt this, in the column marked tangent at bottom, ſtands 10,38816, which is the log. tangent required.

337. But when a logarithm ſine or tangent is propoſed, to find the deg. and minutes belonging to it, then,

Seek in the table, among the proper columns, for the neareſt logarithm to the given one; and the correſponding degrees and minutes will be found; obſerving to reckon them from the top or bottom, according as the column is titled, wherein the neareſt logarithm to the given one is found.

338. It may ſometimes happen that a log. ſine or log. tang. may be wanted to degrees, minutes, and parts of minutes; which may be thus found.

Take the difference between the logs. of the degrees and minutes next leſs, and thoſe next greater, than the given number.

Then for $\frac{1}{4}$, take a quarter of this difference; for $\frac{1}{3}$, take a third; for $\frac{1}{2}$, take a half; for $\frac{2}{3}$. take two thirds; for $\frac{3}{4}$, take three quarters *&c.*

Add the parts taken of this difference to the right hand figures of the log. belonging to the deg. and min. next leſs, and the ſum will be the log. to the deg. min. and parts propoſed.

EXAMPLE I. *Required the log. tang. to* 60°. 56′$\frac{1}{2}$.

Log. tan. 60°. 57′. is	10,25535
Log. tan. 60 56 is	10,25506
The diff. is	29
Its half is	14
Add it to tan. 60°. 56′.	10,25506
Gives tan. 60 56$\frac{1}{2}$	10,25520

EXAMPLE II. *Required the log. ſine to* 32°. 15′$\frac{3}{4}$.

Log. ſine 32°. 16′ is	9,72743
Log. ſine 32 15 is	9,72723
The diff. is	20
Its three fourths is	15
Add it to ſine 32°. 15′.	9,72723
Gives ſine 32 15$\frac{3}{4}$	9,72738

In moſt caſes the work may be done by inſpection.

339. And if a given log. ſine or log. tangent falls between thoſe in the tables; then the degrees and minutes anſwering may be reckoned $\frac{1}{4}$, or $\frac{1}{3}$, or $\frac{1}{2}$ *&c.* minutes more than thoſe belonging to the neareſt leſs log. in the tables, according as its difference from the given one is $\frac{1}{4}$, or $\frac{1}{3}$, or $\frac{1}{2}$ *&c.* of the difference between the logarithms next greater and next leſs than the given log.

SECTION III.

Of the Solution of Plane Triangles.

340. PROBLEM I.

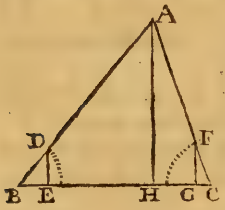
In any plane triangle (ABC) if among the things given there be a ſide and its oppoſite angle, to find the reſt.

Then ſay, *As a given ſide* (AB)
To the ſine of its oppoſite angle; (C)
So is another given ſide, (AC)
To the ſine of its oppoſite angle (B)

Therefore, to find an angle, begin with a ſide oppoſite to a known angle.

Alſo, *As the ſine of a given angle* (B)
To its oppoſite ſide; (AC)
So is the ſine of another given angle (C)
To its oppoſite ſide. (AB)

Therefore, to find a ſide, begin with an angle oppoſite to a known ſide.



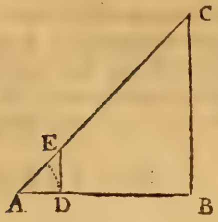
DEM. Take BD = CF = radius of the tables.
Draw DE, AH, FG, each perpendicular to BC. (150)
Then DE and FG are the ſines of the angles B and C. (298)
Now the triangles BDE, BAH, are ſimilar, and ſo are the triangles CFG, CAH.
Therefore BD : DE : : BA : AH. (250)
And (CF=) BD : FG : : CA : AH. (250)
But (BD × AH =) DE × BA = FG × CA. (245)
Therefore DE : CA : : FG : BA. Or, s,∠B : AC : : s,∠C : BA. (246)

SCHOL. Or, by circumſcribing the triangle with a circle, it will readily appear, that the half of each ſide is the ſine of its oppoſite angle. And halves have the ſame proportion as the wholes.

341. PROBLEM II.

In a right angled plane triangle (ABC) if the two ſides containing the right angle (B) are known, to find the reſt.

Then, *As one of the known ſides*, (AB)
To the radius of the tables (or tangent of 45°). (AD)
So is the other known ſide, (BC)
To the tangent of its oppoſite angle. (DE)



DEM. Take AD = radius of the tables.
Then DE perpendicular to AD, is the tangent of the angle A. (299)
And the triangles ADE, ABC, are ſimilar.
Therefore AB : AD : : BC : DE. (250)

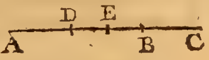
342. PROBLEM III.

In any two quantities, *their half difference added to their half ſum, gives the greater.*

The half diff. ſubtracted from the half ſum, gives the leſs.

And the half ſum taken from the greater, the remainder will be the half difference of thoſe quantities.

Dem. Let AB be the greater, and BC the leſs, of two quantities.
Take $AD = BC$; then BD is their difference.
Biſect DB in E; then $DE = EB$, is the half diff.
And $AD + DE = BC + BE$ (138); therefore AE is the half ſum.
Now $AE + EB = AB$, is the greater
And $AE - ED = (AD =) BC$, is the leſs
Alſo $AB - AE = BE$, is the half diff.



343. PROBLEM IV.

In any plane triangle (ABC); if the three things known, be two ſides (AC, CB) and their contained angle (C), to find the reſt.

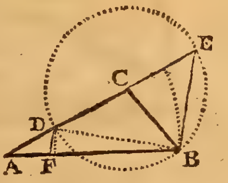
Find the ſum and difference of the given ſides.

Take half the given angle from 90 *degrees, and there remains half the ſum of the unknown angles.* Then ſay

As the ſum of the given ſides,	$AC + CB$
To the difference of thoſe ſides;	$AC - CB$
So is the tangent of half the ſum of the unknown angles,	t. $\frac{1}{2}\,\overline{B + A}$
To the tangent of half the difference of thoſe angles,	t. $\frac{1}{2}\,\overline{B - A}$

Add the half difference of the angles to the half ſum, and it will give the greater angle $= B$.

Subtract the half difference of the angles from the half ſum, and it will give the leſſer angle $= A$.



Dem. On C, with the radius CB, deſcribe a circle, cutting AC produced, in E and D, draw EB, and BD; alſo draw DF parallel to EB.
Then $AE = AC + CB$, is the ſum of the ſides.
And $AD = AC - CB$, is the difference of the ſides.
Now $\angle CDB = \angle CBD$. (194)
And $(CDB + CBD =) 2\,CDB = \angle CBA + \angle A$. (188)
Therefore $\frac{1}{2}\,\overline{\angle CBA + \angle A} = \angle CDB$, is half the ſum of the unknown angles.
And BE is the tangent of CDB, to the radius DB. (299)
Alſo $(CBA - CBD =)\ DBA = \frac{1}{2}\angle CBA - \frac{1}{2}\angle A$. (342)
Therefore $\frac{1}{2}\,\overline{\angle CBA - \angle A} = \angle DBA$, is half the difference of the unknown angles.
And DF is the tangent of DBA, to the radius DB. (299)
Now the triangles AEB, ADF, are ſimilar, DF being parallel to EB.
Therefore $AE : AD :: BE : DF$. (250)
Or $AC + CB : AC - CB :: \text{t. } \frac{1}{2}\,\overline{\angle CBA + \angle A} : \text{t. } \frac{1}{2}\,\overline{\angle CBA - \angle A}$.

344. PROBLEM V.

In a plane triangle (ABC), if the three ſides are known, and the angles required.

From the greateſt angle (B) *ſuppoſe a line* (BD) *drawn perpendicular to its oppoſite ſide, or baſe, dividing it into two ſegments* (AD, DC), *and the given triangle into two right angled triangles* (ADB, CDB): Then ſay

As the baſe, or ſum of the ſegments,	AC
Is to the ſum of the other two ſides;	AB + BC
So is the difference of thoſe ſides,	AB — BC
To the difference of the ſegments of the baſe.	AD — DC

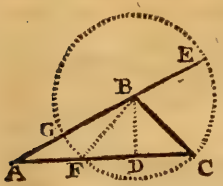
Add half the difference of the ſegments to half the baſe, gives the greater ſegment (AD). (342)

Subtract half the difference of the ſegments from half the baſe, gives the leſſer ſegment (DC). (342)

Then, in each of the triangles (ADB, CDB), *there will be known two ſides, and a right angle oppoſite to one of them; therefore the angles will be found by Problem* I. (340)

When two of the given ſides are equal; *then a line drawn from the included angle, perpendicular to the other ſide, biſects the ſide.* (193)

And the angles being found in one of the right angled triangles, will alſo give the angles of the other.



DEM. Of the foregoing proportion.
In the triangle ABC, the line BD perpendicular to AC, divides AC into the ſegment AD, DC.
On B with the radius BC, deſcribe a circle GCE, cutting AB, continued, in G, E; and AC in F; draw BF.

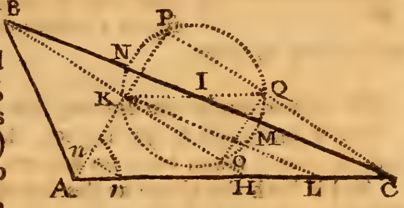
Then DC = DF. (193)
Now AC (= AD + DC) is the ſum of the ſegments.
And AF (= AD — FD) is the difference of the ſegments.
Alſo, AE (= AB + BC) is the ſum of the other ſides.
And AG (= AB — BC) is the difference of thoſe ſides.
But AC × AF = AE × AG. (255)
Therefore AC : AE : : AG : AF. (246)
Or AC : AB+BC : : AB—BC : AD — DC : or = AD — DF.

345.

PROBLEM VI.

In any plane triangle (ABC), the three ſides being known, to find either of the angles.

Put E *and* F *for the ſides including the angle ſought.*
 G *for the ſide oppoſite to that angle.*
 D *for the difference between the ſides* E *and* F.
 Find half the ſum of G *and* D.
 And half the difference of G *and* D.
Then write theſe four logarithms under one another, namely
 The Arithmetical complement of the logarithm of E. (88)
 The Arithmetical complement of the logarithm of F;
 The logarithm of the aforeſaid half ſum of G *and* D;
 The logarithm of the aforeſaid half difference of G *and* D.
Add them together, take half their ſum;
And the degrees and minutes anſwering, being doubled, will give the ſine of the angle ſought.



Dem. In the triangle ABC, let A be the angle ſought.
Take AH = AB, draw BH; and thro' K, the middle of BH, draw AP, which biſects the Angle A, and is perpendicular to BH (193)
Thro' K draw KL, KQ, parallel to BC, AC; which will biſect HC, BC, in L and I; then KL=IC, KI=LC. (119, 248)
And the difference between AC and AB is HC=D; then KI=½ D.

From I with the radius IK deſcribe a circle cutting AP, BH, KQ, BC, in P, O, Q, M, N, and join CQ; now IQ=IK=LC=LH; therefore KQ=HC, and CQ=KH, as the triangles CQI, KHL, are congruous. (189).

Therefore CQ parallel to KH (119) being produced, will meet AP at right angles (144), in the point P by the reverſe of (213).

Then PQ=KO, as the triangles KQP, QOC, are congruous. (185,190)
Now BM= (BI+IM = ½ BC + ½ HC =) $\frac{1}{2}\overline{G+D}$: And BN = $\frac{1}{2}$ G−D.
Alſo BO=CP: For BK= (KH=) CQ, and KO=PQ.
Let A*r*=radius of the tables; then *rn* (parallel to BH)=ſine of ½ ∠ A. (298)

Then the triangles A*nr*, AKB, APC, are ſimilar.
And A*r* : *rn* : : AB : BK; alſo A*r* : *rn* : : AC : (CP=) BO.
Therefore $\overline{Ar}^2 : \overline{rn}^2$: : AC × AB : (BK × BO=) BM × BN. (244, 255)
Or (ſq. rad.=) R^2 : ſq. ſine ½ ∠ A : : AC × AB : $\frac{1}{2}\overline{G+D} \times \frac{1}{2}\overline{G-D}$.

Therefore ſquare of the ſine ½ ∠ A = $\dfrac{\frac{1}{2}\overline{G+D} \times \frac{1}{2}\overline{G-D}}{AC \times AB} \times R^2$. (247)

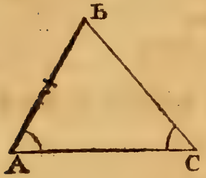
Therefore ſine ½ ∠ A = $\sqrt{\dfrac{\frac{1}{2}\overline{G+D} \times \frac{1}{2}\overline{G-D}}{E \times F}}$; becauſe R=1 the rad. of the tables.

Or

$$\left.\begin{array}{l}\text{Or Log. s, }\tfrac{1}{2}\angle\text{A}=\dfrac{\text{Log. }\frac{1}{2}\,\overline{\text{G}+\text{D}}+\text{Log. }\frac{1}{2}\,\overline{\text{G}-\text{D}}-\text{Log. E}-\text{Log. F.}}{2}\\ \text{Or L. s, }\tfrac{1}{2}\angle\text{A}=\dfrac{\text{l. E}+\text{l. F}+\text{L. }\frac{1}{2}\,\overline{\text{G}+\text{D}}+\text{L }\frac{1}{2}\,\overline{\text{G}-\text{D}}}{2}\end{array}\right\}\begin{array}{l}85\\86\\91\end{array}$$

Where L. ſtands for logarithm, and l. for Arith. comp. of the logarithm.

346. Every poſſible caſe in plane Trigonometry may be readily ſolved by the preceding Problems, obſerving the following Precepts.



I. Make a rough draught of the triangle, and put the letters, A, B, C, at the angles.

II. Let ſuch parts of this triangle be marked, as repreſent the things which are given in the queſtion. Thus, mark a given ſide with a ſcratch acroſs it; And a given angle by a little crooked line; as in the figure; where the ſide AB, and the angles A and C, are marked as given.

III. If two angles are known, the third is always known.

For if one angle is 90 degrees, the other given angle (which (187) will be acute) taken from 90 degrees, leaves the third angle.

And if both the given angles are oblique; their ſum taken from 180 degrees, gives the other angle.

IV. Compare the given things together, and thereby determine to which Problem the queſtion propoſed belongs.

V. Then according as the Problem directs, perform the preparatory work; and write down, under one another, in four lines, (or more if neceſſary), the literal ſtating; expreſſing each angle by a letter, or by three; each line by two letters; and the ſums, or differences, of lines, by proper marks.

VI. Againſt ſuch terms that are known, write their numeral value as given in the queſtion, or as found in the preparatory work; and againſt theſe numbers write their logarithms; thoſe for the lines being found (by 81) in the table of the logarithms of numbers; and thoſe for the angles, found (by 336) in the table of logarithm ſines and tangents: Obſerving that an Arithmetical complement (ſee 88) is always uſed in the firſt term: And that when an angle is greater than 90 degrees, its ſupplement is uſed.

VII. Add theſe logarithms together, and ſeek the ſum (81) in the log. numbers, when a line is wanted; or (337) in the log. ſines or tangents, when an angle is wanted. Then the number or degree, anſwering to a log. the neareſt to the ſaid ſum, will be the thing required.

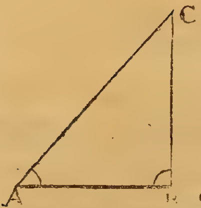
347.

A SYNOPSIS

Of the Rules in Plane Trigonometry.

PROB	*Given*	*Required*	SOLUTION.
I. ſee art. 340	All the angles and one ſide	either of the other ſides	Since two angles are known, the third is known. And, As ſin. of ∠ opp. to ſide given, is to that opp. ſide; So ſin. of another angle, to its opp. ſide.
	Two ſides and an ∠ oppoſ. to one ſide	The angle opp. to the other giv. ſide	As one given ſide, is to the ſine of its opp. angle; So is t'other given ſide, to the ſine of its opp. angle. Then two angles being known the third is known And the other ſide is found as before.
II. art. 341	Two ſides and the included right ∠	either of the other angles.	As one of the given ſides, is to the Radius; So is the other given ſide, to the tan. of its opp. ∠. Then two ∠s being known, the third is known The other ſide is found by opp. ſides and ∠s.
III. art. 343	Two ſides and the included oblique angle	The other angles	Find the ſum and diff. of the given ſides. Take $\frac{1}{2}$ giv. ∠ from 90°. leaves $\frac{1}{2}$ ſum of other ∠s. Then, As ſum ſides, is to diff. ſides; So tan. $\frac{1}{2}$ ſum oth. ∠s, to tan. $\frac{1}{2}$ diff. thoſe ∠s. The $\frac{1}{2}$ ſum ∠s $\left\{\begin{matrix}+\\-\end{matrix}\right\}$ $\frac{1}{2}$ diff. ∠s, gives $\left\{\begin{matrix}\text{greater } \angle\\\text{leſſer } \angle.\end{matrix}\right.$ Find the other ſide by opp. ſides and angles.
IV. art. 344	The three ſides	All the angles	Draw a line perp. to the greateſt ſide, from the opp. ∠, dividing that ſide into two parts. Then, As the longeſt ſide : is to ſum other 2 ſides; So is the diff. thoſe ſides : to the diff. parts of longeſt Then $\frac{1}{2}$ long. ſide $\left\{\begin{matrix}+\\-\end{matrix}\right\}$ $\frac{1}{2}$diff. pts. gives the $\left\{\begin{matrix}\text{great}\\\text{leſſer}\end{matrix}\right\}$ part. Now the ſaid perp. cuts the triangle into 2 right ∠d. ones. In both, are known the Hyp. a leg. and the right ∠. The angles are found by Problem I.
V. art. 345	The three ſides	Either Angle	Having choſe which angle to find; call the ſides including that angle E and F. The ſide opp. that ∠, call G. Put D for the difference between E and F. Find the half ſum, and half diff. of G and D. Then write theſe four logs. under one another *Viz.* $\left\{\begin{matrix}\text{The Ar. Co. log. of E, The Ar. Co. Log. of F,}\\\text{The Log. of } \frac{1}{2} \text{ ſum, And the log. of } \frac{1}{2} \text{ diff.}\end{matrix}\right.$ Add the four logs. together, take half their ſum. Seek it among the log. ſines; and the correſponding deg and min. doubled, is the angle ſought.

348. Example I. *In the plane Triangle* ABC.



Given AB = 195 *Poles*
∠B = 90°. 00′
∠A = 47 55
Required the other parts.

For the linear Solution.

1ſt. Draw AB equal to 195 poles, taken from a ſcale of equal parts.
2d. From B, draw BC making with AB an angle of 90°. (175)
3d. From A, draw AC, making with AB an angle of 47°. 55′; and meeting BC in the point C.
Then is the triangle ABC ſuch whoſe parts correſpond with the things given; and the ſides CA, CB, being applied to the ſcale that AB was taken from, their meaſures will be found, *viz.* AC=291; and BC=216.

For the numeral Solution, or Computation.

Since two angles are known; Therefore

From 90°. 00′=∠B
Take 47 55=∠A
Remains 42 05=∠C

Now in this triangle, there are known all the angles and one ſide; therefore among the known things, there is a ſide and its oppoſite angle; which belongs to the firſt problem.
Then to find the ſide AC, begin with the angle C oppoſite AB.

As the ſine of the ∠ C	Or thus, As s,∠C=42°. 05′	0,17379 A.C.
To the oppoſite ſide AB	To AB=195 po.	2,29003
So the ſine of the ∠ B	So s,∠B=90°. 00′	10,00000
To the oppoſite ſide AC.	To AC=291 po.	2,46382

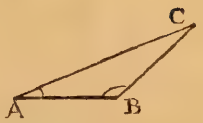
And to find the ſide BC, begin with the angle C oppoſite AB.

As the ſine of the ∠ C,	Or thus, As s,∠C=42°. 05′	=0,17379 A.C.
To the oppoſite ſide AB;	To AB=195 po.	=2,29003
So the ſine of the ∠ A,	So s,∠A=47°. 55′	=9,87050
To the oppoſite ſide BC.	To BC=216 po.	=2,33432

So that AC is 291 poles, and BC is 216 poles.
The letters A.C. ſtanding on the right of the firſt line, ſignify the arithmetical complement of the log. ſine of 42°. 05′. (See 88)

349. EXAMPLE II. *In the plane Triangle* ABC.

Given AB = 117 miles.
∠B = 134° 46′
∠A = 22 37
Required the other parts.



FOR THE LINEAR SOLUTION OR CONSTRUCTION.

Make AB = 117 equal parts; at A make an angle = 22° 37′; and at B make an angle of 134° 46′; then the lines making with AB thoſe angles will meet in C, and form the triangle propoſed.

And the meaſure of BC will be 117, and of AC 216.

BY COMPUTATION. See art. 340.

Since two angles are known,

Namely ∠B =	134° 46′	Now from	180° 00′	And from	180° 00′
∠A =	22 37	Take	157 23	Take	134 46
Their ſum =	157 23	Leaves ∠C =	22 37	The ſup^t. ∠B =	45 14

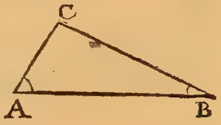
Since the angle C = ∠A.
Therefore BC = AB.

(194)

To find the ſide AC.		
As s, ∠C = 22° 37′	0,41503	A.C.
To AB = 117 M.	2,06819	
So s, ∠B = 134° 46	9,85125	ſup.
To AC = 216 M.	2,33447	

350. EXAMPLE III. *In the plane Triangle* ABC.

Given AB = 408 yards.
∠B = 22° 37′
∠A = 58° 07
Required the other parts.



CONSTRUCTION.

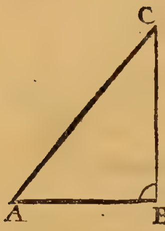
Make AB = 408 yards, or equal parts; make the angle A = 58° 07′; and the ∠B = 22° 37′; then the lines forming theſe angles will meet in C; and the meaſure of AC is 159 miles, and of BC is 351.

COMPUTATION. See art. 340.

Two angles being known, *viz.* ∠A =	58° 07′	From	180° 00′
∠B =	22 37	Take	80 44
Their ſum =	80 44	Leaves	99 16 = ∠C.

To find the ſide AC.			To find the ſide BC.		
As s, ∠C = 99° 16′	0,00570	A.C.	As s, ∠C = 99° 16	0,00570	A.C.
To AB = 408	2,61066		To AB = 408	2,61066	
So s, ∠B = 22° 37′	9,58497		So s, ∠A = 58° 07′	9,92897	
To AC = 159	2,20133		To BC = 351	2,54533	

In theſe operations the ſupplement of the angle C is uſed.



351. EXAMPLE IV. *In the plane Triangle* ABC.

Given AB=195 } Furlongs.
AC=291 }
∠B=90° 00′.
Required the reſt.

CONSTRUCTION.

Make AB=195 equal parts; draw BC, making an angle at B=90° 00′: From A with 291 equal parts cut BC in C, and draw AC.

Then the ∠ A meaſured on the ſcale of chords will be about 48 deg. and ∠ C about 42°: Alſo BC on the equal parts, meaſures about 216.

COMPUTATION.

Here being two ſides and an angle oppoſite to one of them, the ſolution falls under problem the firſt. See art. 340.

To find the angle C.

As	AC=291 F.	7,53611 A.C.
To s,∠B=90° 00′		10,00000
So	AB=195 F.	2,29003
To s∠C=42° 05′		9,82614

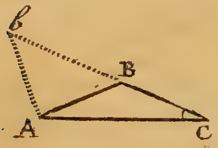
From 90° 00′
Take 42 05=∠C
Leaves 47 55=∠A.

To find the ſide BC.

As s,∠B=90° 00′	10,00000
To AC=291 F.	2,46389
So s,∠A=47° 55′	9,87050
To BC=216 F.	2,33439

Here the ſine of 90° 00′ or radius being the firſt term, its Arith. Comp. being 0, is not taken.

352. EXAMPLE V. *In the plane Triangle* ABC



Given AC=216 } Yards.
AB=117 }
∠C=22° 37′.
Required the reſt.

CONSTRUCTION.

Make AC=216 yards; the ∠C=22° 37′; and draw CB: Then from A with 117 yards, cut CB in *b* or in B; and either of the triangles AC *b* or ACB will anſwer the conditions propoſed: But the triangle to be uſed, is generally determined by ſome circumſtances in the queſtion it belongs to. Thus if the angle oppoſite to AC is to be obtuſe, the triangle is ABC.

COMPUTATION.

The ſolution belongs to problem the firſt. See art. 340.

To find the angle B.

As	AB=117 Y.	7,93181
To	s,∠C=22° 37′	9,58497
So	AC=216 Y.	2,33445
To	s,∠B=134° 46′	9,85123

∠C+∠B=157 23

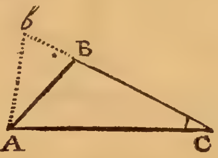
From 180° 00′
Take 157 23=∠C+∠B
Leaves 22 37=∠A.

And as the ∠A=∠C
Therefore BC=AB. (194)

If the angle required be obtuſe, ſubtract the deg. and min. correſponding to the fourth log. from 180; the remainder is the ∠ B. For the fourth log. gives the ∠ *b*, which is the ſupplement to the angle B. (194, 186)

353. EXAMPLE VI. *In the plane Triangle* ABC.

Given AC=408 }
AB=159 } Fathoms.
∠C=22° 37′.
Required the reſt.



CONSTRUCTION.

Make AC=408 fathoms; the ∠C=22° 37′; and draw C*b*; from A with 159 fathoms cut C*b* in *b* or in B, and draw A*b* or AB:
Then if the angle oppoſite to AC is to be acute, the triangle AC*b* is that which is required; but if the angle is to be obtuſe, ACB is the triangle ſought.

COMPUTATION. See art. 340.

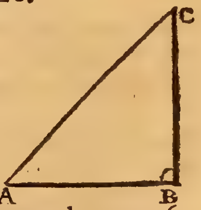
Here being a ſide and its oppoſite angle known, the ſolution falls under problem the firſt; the ∠B is to be obtuſe.

To find the angle B, obtuſe.		To find BC.	
As AB=159 F.	7,79860	As s,∠C=22° 37′	0,41503
To s,∠C=22° 37′	9,58497	To AB=159 F.	2,20140
So AC=408 F.	2,61066	So s,∠A=58° 04′	9,92874
To s,∠B=99° 19′	9,99423	To BC=350,9	2,54517

∠C+∠B=121 56 taken
From 180 00
Leaves ∠A= 58 04

354. EXAMPLE VII. *In the plane Triangle* ABC.

Given AB=195 }
BC=216 } Furlongs.
∠B=90° 00′.
Required the reſt.



CONSTRUCTION.

Make the angle ABC=90°; take BA=195 equal parts, and BC=216; and draw AC; then ABC is the triangle propoſed; wherein the parts required may be meaſured by the proper ſcales.

COMPUTATION. See art. 341.

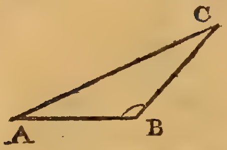
As two ſides and the contained right angle are known, the ſolution belongs to problem the ſecond.

To find the angle A.		To find AC.	
As AB=195 F.	7,70996	As s,∠A=47° 55′	0,12950
To Radius=45° 00′	10,00000	To BC=216 F.	2,33445
So BC=216 F.	2,33445	So s,∠B=90° 00′	10,00000
To t,∠A=47° 55′	10,04441	To AC=291 F.	2,46395

90 00
∠C=42 05

355.

355. **EXAMPLE VIII.** *In the plane triangle* ABC.



Given AB = 117 } Yards.
BC = 117 }
∠B = 134° 46′.
Required the reſt.

CONSTRUCTION.

Make the ∠ ABC = 134° 46′; take BA and BC each equal to 117 equal parts, from the ſame ſcale, and draw AC; then is the triangle ABC equal to that propoſed; and the parts required meaſured on their proper ſcales will give their values.

COMPUTATION. See art. 343.

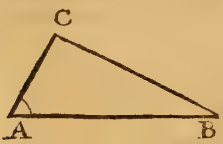
Now as AB and AC are equal; therefore the angles A and C are alſo equal.

From	180° 00′	
Take	134 46 = ∠B	
Leaves	45 14 = ∠A + ∠C.	
The half	22 37 = ∠A = ∠C.	

To find AC.

As s, ∠A = 22° 37′	0,41503
To BC = 117 Y.	2,06818
So s, ∠B = 134° 46′	9,85125
To AC = 216 Y.	2,33446

356. **EXAMPLE IX.** *In the plane Triangle* ABC.



Given AB = 408 } Fathoms.
AC = 159 }
∠A = 58° 07′
Required the reſt.

CONSTRUCTION.

Make an angle CAB = 58° 07′; take AC = 159, AB = 408, from the ſame ſcale of equal parts; and draw CB; then will the triangle ACB be equal to that which was propoſed.

COMPUTATION.

Here being two ſides and their contained angle known, the ſolution belongs to art. 343.

AB = 408
AC = 159
AB + AC = 567 = ſum of ſides
AB − AC = 249 = diff. of ſides.

The half of 58° 07′
Is 29 03½ which
Taken from 90 00
Leaves 60 56½ = ½∠C + ½∠B.

To find the angles.

As AB + AC = 567	7,24642
To AB − AC = 249	2,39620
So t, ½∠C + ∠B = 60° 56½ (See 338)	10,25520
To t, ½∠C − ∠B = 38° 19½	9,89782

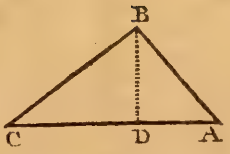
Then (342) 99 16 = ∠C (195)
And 22 37 = ∠B

To find AC.

As s, ∠C = 99° 16′	0,00570
To AB = 408	2,61066
So s, ∠A = 58° 07′	9,92897
To BC = 351	2,54533

357. **Example X.** *In the plane Triangle* ABC.

Given AB=195
BC=216
AC=291
Required the angles.



Construction.

Make CA=291 equal parts; from C with 216, deſcribe an arc B; from A with 195 cut the arc B in B; draw BC, BA, and the triangle is conſtructed; then the angles may be meaſured by the help of a ſcale of chords.

Computation.

The three ſides being given, the ſolution falls under either Problem V. or Problem VI. But that the uſe of theſe Problems may be ſufficiently illuſtrated, the ſolutions according to both of them are here annexed.

Solution by Problem V. (344)

From the angle B, draw BD perpendicular to CA, which will be divided into the ſegments CD, DA, whoſe ſum AC is known.

Now BC=216
And AB=195
BC+AB=411= ſum of ſides
BC—AB= 21= diff. of the ſides

To find the diff. of the ſegments.

As AC	=291	7,53611
To BC+AB	=411	2,61384
So BC—AB	= 21	1,32222
To CD—AD	= 29,66	1,47217

Now the half of 291 is 145,5
And the half of 29,66 is 14,83
Therefore (342) the ſum 160,33=CD; or CD=160,3
the diff. 130,67=AD; or AD=130,7

Then in the triangle CDB.

As BC	=216	7,66555
To s, ∠CDB	=90° 00′	10,00000
So CD	=160,3	2,20493
To s, ∠CBD	=47 55	9,87048
Wh. taken from	90 00	
Leaves ∠C	=42 05	

And in the triangle ADB.

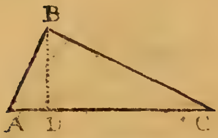
As AB	=195	7,70996
To s, ∠ADB	=90° 00′	10,00000
So AD	=130,7	2,11628
To s, ∠ABD	=42 05	9,82624
Wh. taken from	90 00	
Leaves ∠A	=47 55. & ∠B=90° 0′.	

Solution by Problem VI. (345)

To find the angle C.
Put E=291=AC
F=216=BC
G=195=AB.
D= 75=E—F
2) 270 (135=½ G+D
2) 120 (60=½ G—D

Then To Ar. Co. log. E	=291	7,53611
Add. Ar. Co. log. F	=216	7,66555
And the log. ½ G+D	=135	2,13033
Alſo the log. ½ G—D	= 60	1,77815
The half of this ſum		2) 19,11014
Is the log. ſine of	21° 02′½ (339)	9,55507
Which doubled, gives	42° 05′=∠C.	

The angle C being found, the other angles may be found by Prob. I.



358. **Example XI.** *In the plane Triangle* ABC.

Given AC=408
BC=351
AB=159
Required the angles.

CONSTRUCTION.

The conſtruction and menſuration is performed as in the laſt Ex.

COMPUTATION BY PROB. V. art. 344.

From the ∠ B draw the perpendicular BD; and find the ſegments AD, DC; which may be done without logarithms.

Thus BC=351
AB=159
BC+AB=510
BC—AB=192

Then (46) As 408 : 510 : : 192 : 240=DC—DA.
For 192×510=97920; which divided by 408 gives 240.

Now half of 408=204; and half of 240 is 120.

Then 204+120=324=DC; and 204—120=84=DA.

In the triangle ADB.

As	AB	=159	7,79860
To s, ∠D		=90° 00′	10,00000
So	AD	=84	1,92428
To s, ∠ABD		=31° 53′	9,72288
And ∠A		=58 07	

In the triangle BDC.

As	BC	=351	7,45469
To s, ∠D		=90° 00′	10,00000
So	DC	=324	2,51054
To s, ∠CBD		=67° 23′	9,96523
And ∠C		=22 37	

Then ∠ABD+∠CBD=∠ABC=99° 16′.

COMPUTATION BY PROB. VI. art. 345.

To find the angle C.

Put E=408=AC
F=351=BC
G=159=AB
D= 57=E—F

2) 216 (108=$\frac{1}{2}\overline{G+D}$

2) 102 (51=$\frac{1}{2}\overline{G-D}$

Then To Ar. Co. log.	E	=408	7,38934
Add. Ar. Co. log.	F	=351	7,45469
And the log.	$\frac{1}{2}\overline{G+}$	=108	2,03342
Alſo the log.	$\frac{1}{2}G-D$	= 51	1,70757
The half of this ſum			2) 18,58502
Is the log. ſine of 11° 18′½			9,29251

Which doubled, is 22° 37′=∠C.

Now the angle C being known, the other angles may be found by Prob. I. But for a farther illuſtration of Prob. VI. the work for another angle is here repeated.

To find the angle B.

Put E=351=BC
F=159=AB
G=408=AC
D=192=E—F

2) 600 (300=$\frac{1}{2}\overline{G+D}$

2) 216 (108=$\frac{1}{2}\overline{G-D}$

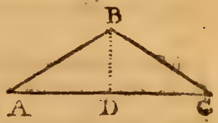
Then To Ar. Co. log.	E	=351	7,45469
Add Ar. Co. log.	F	=159	7,79860
And the log.	$\frac{1}{2}\overline{G+D}$	=300	2,47712
Alſo the log.	$\frac{1}{2}G-D$	=108	2.03342
The half of this ſum			2) 19,76383
Is the log. ſine of 49° 38′			9,88191

Which doubled, is 99° 16′=∠B.

359.

359. EXAMPLE XII. *In the plane Triangle* ABC.

Given AB=117
BC=117
AC=216
Required the angles.



CONSTRUCTION.

The conſtruction of this triangle, and the meaſuring of the angles, is performed as in the X. and XI. Examples.

COMPUTATION.

In the triangle ABC, as AB=BC; therefore the angles A and C are equal (194); and the perpendicular BD biſects the ſide AC; ſo that the right angled triangles ADB, CDB, are congruous; conſequently, the angles being found in one triangle, will give thoſe of the other.

Now in the triangle ADB, the ſide AB=117; the ſide AD, $=\frac{1}{2}$ AC, is 108; and the ∠ D is 90° 00′: Here being a ſide and its oppoſite angle the ſolution belongs to Prob. I.

To find the angle ABD.		
As	AB =117	7,93181
To	s,∠D =90° 00′	10,00000
So	AD =108	2,03342
To	s,∠ABD=67° 23′	9,96523
Wh.taken from	90 00	
Leaves	22 37=∠A=∠C.	

And 67° 23′ doubled

Gives 134 46=∠ABC.

A like proceſs is to be uſed in every triangle, wherein are two equal ſides.

In the foregoing examples are contained all the variety that can happen in the ſolutions of plane triangles, conſidered only with regard to their ſides and angles: But beſides the methods ſhewn of reſolving ſuch triangles by conſtruction and computation; there is another way to find theſe ſolutions, called Inſtrumental; and this is of two kinds, *viz.* either by a ruler called a Sector, or by one called the Gunter's ſcale: The method by the ſector, the curious reader may ſee in many books, particularly in a treatiſe on Mathematical Inſtruments publiſhed in the year 1747: But the other being in great uſe at ſea, it will be proper in this place to treat of it.

SECTION IV.

360. *Deſcription and Conſtruction of the Gunter's Scale.*

Mr. *Edmund Gunter*, Profeſſor of Aſtronomy at *Greſham* College, did ſome time about the year 1624, apply to a flat Ruler the Logarithms of numbers; this he effected, by taking from a ſcale of equal parts the lengths expreſſed by the figures in thoſe logarithms, and transferring them to a line or ſcale drawn on ſuch a ruler; and this is the line, which from his name, is called the *Gunter's Line*: He alſo, in like manner, conſtructed lines containing the logarithms of the ſines and tangents; and ſince his time there have been contrived other logarithmic ſcales adapted to various purpoſes.

The Gunter's ſcale is a ruler commonly two feet long; having on one of its flat ſides ſeveral lines or logarithmic ſcales; and the other ſide various other ſcales; which, to diſtinguiſh them from the former, may be called natural ſcales.

While the reader is peruſing what follows, it is proper he ſhould have a Gunter's ſcale before him.

361. *Of the natural Scales.*

The half of one ſide is filled with different ſcales of equal parts, for the convenience of conſtructing a larger, or ſmaller figure: The other half contains ſcales of Rhumbs, marked Ru; Chords, marked Ch; Sines, marked Sin; Tangents, marked Tan; Secants, marked Sec; Semitangents, denoted by S.T. and Longitude, diſtinguiſhed by M.L. The deſcriptions and uſes of theſe ſcales will be conſidered hereafter, in the places where they will be wanted.

362. *Of the Logarithmic Scales.*

On the other ſide of the ſcale are the following lines;

I. A line marked S.R. (ſine rumbs), which contain the logarithm ſines of the degrees to each point and quarter point of the compaſs.

II. A line ſigned T.R. (tang. rumbs), whoſe diviſions correſpond to the logarithm tangents of the ſaid points and quarters.

III. A line marked Num. (numbers), wherein the logarithms of numbers are laid down.

IV. A line marked ſin. containing the log. ſines.

V. A line of log. verſed ſines, marked V.S.

VI. A line of log. tangents, marked Tan.

VII. A meridional line ſigned Mer.

VIII. A line of equal parts, marked E.P.

363. I. *Of the Line of Numbers.*

The whole length of this line or ſcale, is divided into two equal ſpaces, or intervals; the beginning, or left hand end of the firſt, is marked 1; the end of the firſt interval, and beginning of the ſecond, is alſo marked 1; and the end of the ſecond interval, or end of the ſcale, is marked with 10: Both theſe diſtances are alike divided, beginning at the left hand ends, by laying down in each, the lengths of the logarithms of the numbers 20, 30, 40, 50, 60, 70, 80, 90; taken from a ſcale of equal parts, ſuch that 10 of its primary diviſions make the length of one interval: And the intermediate diviſions are found, by taking the logarithms of like intermediate numbers.

From this conſtruction it is evident, that when the firſt 1 ſtands for 1, the ſecond 1 ſtands for 10, and the end 10 denotes 100;

And if the firſt 1 is called	the 2d. 1 ſtands for	And the 10 at the end ſtands for
10,	100,	1000;
100,	1000,	10000;
&c.	*&c.*	*&c.*
$\frac{1}{10}$,	1,	10;
$\frac{1}{100}$,	$\frac{1}{10}$,	1;
&c.	*&c.*	*&c.*

And the primary and intermediate diviſions in each interval, muſt be eſtimated according to the values ſet on their extremities, *viz.* at the beginning, middle, and end of the ſcale.

Now the examples moſt proper to be worked by this ſcale, are ſuch wherein the numbers concerned do not exceed 1000; and then the firſt 1 ſtands for 10, the middle 1 for 100, and the 10 at the end for 1000: The primary diviſions in the firſt interval, *viz.* 2, 3, 4, 5, 6, 7, 8, 9, ſtand for 20, 30, 40, 50, 60, 70, 80, 90, and the intermediate diviſions ſtand for units. In the ſecond interval, the primary diviſions ſigned 2, 3, 4, 5, 6, 7, 8, 9, ſtand for 200, 300, 400, 500, 600, 700, 800, 900; each of theſe diviſions are alſo divided into ten parts, which repreſent the intermediate tens. Between 100 and 200, the diviſions for tens are each ſubdivided into five parts; ſo that theſe leſſer diviſions ſtand for two units. The tens between 200 and 500, are divided into two parts, each ſtanding for five units: The units between the tens from 500 to 1000 are to be eſtimated by the eye; which by a little practice is readily done.

From this deſcription it will be eaſy to find the diviſion repreſenting a given number not exceeding 1000: Thus the number 62, is the ſecond ſmall diviſion from the 6, between the 6 and 7 in the firſt interval: The number 435 is thus reckoned; from the 4 in the ſecond interval, count towards the 5 on the right, three of the larger diviſions, and one of the ſmaller; and that will be the diviſion expreſſing 435. And the like of other numbers.

364. II. *For the Line of Sines.*

This ſcale terminates at 90 degrees, juſt againſt the 10 at the end of the line of numbers; and from this termination the degrees are laid backwards, or from thence towards the left: Now ſeeking in a table of logarithm ſines, for the numbers expreſſing their arithmetic complements, without the index, take thoſe numbers from the ſcale of equal parts the logs. of the numbers were taken from, and apply them to the ſcale of ſines from 90°, and they will give the ſeveral diviſions of this ſcale.

Thus the arith. comp. of the log. ſines (or the co-ſecants) abating the index, of 10°, 20°, 30°, 40°, *&c.* are the numbers 76033, 46595, 30103, 19193, *&c.* then the equal parts to theſe numbers, laid from 90°, will give the diviſions for 10°, 20°, 30, 40°, *&c.* and the like for the intermediate degrees.

Proceeding in this manner, the arith. comp. of the ſine of 5° 45′ will be about equal to 10 of the primary diviſions of the ſcale of equal parts, or to one interval in the log. ſcale; ſo that a decreaſe of the index by unity, anſwers to one interval; then a decreaſe of the index by 2 anſwers to 2 intervals, or the whole length of the log. ſcale; and this happens about the ſine of 35 min. and the diviſions anſwering to the ſine of a little above 3 min. *viz.* 3′ 26″ will be equal to 3 intervals; and the ſine of about 26″ will be 4 intervals *&c.* ſo that the ſine of 90° being fixed, the beginning of the ſcale is vaſtly diſtant from it.

'Tis uſual to inſert the diviſions to every 5 minutes, as far as 10 degrees; from 10° to 30°, the ſmall diviſions are of 15 minutes each; from 30° to 50°, contains every half degree; from 50° to 70°, are only whole degrees; the reſt are eaſily reckoned.

365. III. *For the Line of Tangents.*

As the tangent of 45 degrees is equal to the radius, or ſine of 90°; therefore 45° on this ſcale, is terminated directly oppoſite to 90° on the ſines; and the ſeveral diviſions of this ſcale of log. tangents are conſtructed in the ſame manner as thoſe of the ſines, by applying their arith. comp. backwards from 45°, or towards the left hand.

The degrees above 45, are to be counted backwards on the ſcale: Thus the diviſion at 40, repreſents both 40° and 50°; the diviſion 30, ſerves for 30° and 60°; and the like of the other diviſions, and their intermediates.

366. IV. *For the Line of Verſed Sines.*

This line begins at the termination of the numbers, ſines and tangents: But as the numbers on thoſe lines deſcend from the right to the left, ſo theſe aſcend in the ſame direction: Now having a table of logarithmic verſed ſines to 180 degrees, let each log. verſed ſine be ſubtracted from that of 180 degrees; then the remainders being ſucceſſively taken from the ſaid ſcale of equal parts, and laid on the ruler backwards from the common termination, the ſeveral diviſions of this ſcale will be obtained.

The numbers for each 10 deg. are in the following table.

Deg.	Numb.	D.	Numb.	D.	Numb.	Deg.	Numb.	Deg	Numb.	Deg.	Numb.
10	0,0033	40	0,0540	70	0,1733	100	0,3839	130	0,7481	160	1,5207
20	0,0133	50	0,0854	80	0,2315	110	0,4828	140	0,9319	170	2,2194
30	0.0301	60	0,1249	90	0.3010	120	0,6021	150	1,1740	180	10,3010

The other ſcales will be deſcribed in their proper places.

367. *Demonſtration of the foregoing conſtructions.*

That of the log. numbers, is evident from the nature of logarithms.

For the Sines and Tangents.

Now co-ſine : rad. : : rad. : ſecant (329). Then coſ. x ſecant = 1
ſine : rad. : : rad. : co-ſec. (330). ſine x co-ſec. = 1 } 245
tang. : rad. : : rad. : co-tan. (331). tan. x co-tan. = 1

The radius of the tables being ſuppoſed equal to 1.

Hence it is evident, that in either caſe, one of the quantities will be equal to the quotient of unity divided by the other.

But diviſion is performed, by ſubtraction with logarithms.

And to ſubtract a log. is the ſame as to add its arith. comp.

Conſequently the logarithmic co-ſine and ſecant of the ſame degrees, are the arithmetical complements of one another.

And ſo are the logarithmic ſines and co-ſecants: Alſo the logarithmic tangents and co-tangents are the arith. comp^s. of one another.

368. Now as the arith. comp. of any number, is what that number wants of unity in the next ſuperior place.

Therefore every natural ſine and its arith. comp. together make the radius.

And the ſines begin at one end of a radius, and end in 90° at the other end.

Therefore in a ſcale of ſines, the arith. comp. of any ſine, or its co-ſecant, laid backwards from 90° gives the diviſion for that ſine. And the like muſt happen in a ſcale of log. ſines.

369. Alſo, as the logarithmic tangents and co-tangents are the arith. comp. of one another. Therefore in a ſcale of log. tangents, the diviſions to the degrees both under and above 45, are equally diſtant from the diviſion of 45°.

Conſequently the diviſions ſerving to the degrees under 45, will ſerve, by reckoning backwards, for thoſe above 45.

370. *For the Verſed Sines.*

Although the numbers in the line of verſed ſines aſcend from right to left, yet they are only the ſupplements of the real verſed ſines, whoſe order in numbering is the ſame as the ſines, that is from left to right: But as the beginning of the verſed ſines falls without the *ruler*, therefore 'tis moſt convenient to lay down the diviſions from the point where the verſed ſines terminate at 180 degrees, that is againſt 90° on the ſines.

Now 'tis evident that the diviſions laid off from this termination muſt be the differences between the log. verſed ſines of the ſeveral degrees &c. and that of 180 degrees.

SECTION V.

371. *The uſe of the Gunter's Scale in Plane Trigonometry.*

When a Trigonometrical queſtion is to be ſolved by the Gunter's ſcale, it muſt firſt be ſtated by the precepts to that problem under which the queſtion falls, whether it be by oppoſite ſides and angles, or by two ſides and their included angle, or by the three ſides.

372. In all proportions wrought by the Gunter's ſcale, when the firſt and ſecond terms are of the ſame kind, then

The extent from the firſt term to the ſecond, will reach from the third term to the fourth.

Or, when the firſt and third terms are of the ſame kind

The extent from the firſt term to the third, will reach from the ſecond term to the fourth.

That is, ſet one point of the compaſſes on the diviſion expreſſing the firſt term, and extend the other point to the diviſion expreſſing the ſecond (or third) term; then, without altering the opening of the compaſſes, ſet one point on the diviſion repreſenting the third term (or ſecond term), and the other point will fall on the diviſion ſhewing the fourth term or anſwer.

In working by theſe directions, it is proper to obſerve.

273. Firſt. The extent from one ſide to another ſide, is to be taken from the ſcale of Numbers; and the extent from one angle to another is to be taken from the ſcale of ſines, in working by oppoſite ſides and angles; or from the ſcale of tangents, in working by two ſides and the included angle.

Secondly. When the extent from the firſt term to the ſecond (or third) is decreaſing, or from the right to the left, then the extent from the third term (or ſecond) muſt be alſo decreaſing; that is, applied from the right towards the left: And the like caution is neceſſary when the extent is from the left towards the right.

The precepts being carefully attended to, what follows will be readily underſtood.

374. In Example I. See article 348.

As s,∠C : AB : : s,∠B : AC. Or s,42° 05′ : 195 : : s,90° 00′ : Q, where Q ſtands for the number ſought.

Now the extent from 42° 05′ to 90° 00′, taken on the ſcale of ſines, and applied to the ſcale of numbers, will reach from 195 to 291. See art. 364.

Alſo. As s,∠C : AB : : s,∠A : BC. Or s,∠42° 05′ : 195 : : s, 47° 55′ : Q.

Then the extent from 42° 05′ to 47° 55′ on the ſines, being applied to the numbers, will reach from 195 to 216. See art. 363.

In each of theſe operations, the firſt extent was from the left to the right, or increaſing; therefore the ſecond extent muſt be from left to the right.

375. In Example IV. See art. 351.

As AC : s,∠B : : AB : s,∠C. Or 291 : s,90° 00′ : : 195 : Q.

Here the extent from 291 to 195, taken on the numbers, and applied to the ſines, will reach from 90° 00′ to 42° 05′.

The firſt extent being from the right towards the left, or decreaſing; therefore the ſecond extent muſt be alſo from the right to the left.

In Example VII. See art. 354.

As AB : Rad. : : BC : t,∠A. Or 195 : t,45° 00′ : : 216 : Q.

Then the extent from 195 to 216 on the numbers, will reach from 45° 00′ to 47° 55′ on the tangents.

Here the firſt extent being from left to right, or increaſing; therefore the ſecond extent muſt alſo be increaſing: Now on the tangents, this increaſe above 45° does not proceed from left to right, but from right to left, the ſame way that the decreaſe proceeds (365); conſequently the diviſion which the point falls on for the fourth term, muſt be eſtimated according as the firſt extent is increaſing or decreaſing.

Thus had the proportion been,

As BC : Rad. : : AB : t,∠C. Or 216 : t,45° 00′ : : 195 : Q.

Then the extent from 216 to 195 on the numbers, will reach from 45° 00′ to 42° 05′, eſtimated as decreaſing.

376. When two ſides and the included angle are given, and the tangent of half the difference of the unknown angles is required.

Then, on the line of numbers take the extent from the ſum of the given ſides to their difference; and on the line of tangents apply this extent from 45° downwards, or to the left; let the point of the compaſſes reſt where it falls, and bring the other point (from 45°) to the diviſion anſwering to the half ſum of the unknown angles; then this extent applied from 45° downwards, will give the half difference of the unknown angles: Whence the angles may be found. (342)

In Example IX. See art. 356.

As $AB+AC : AB-AC :: t, \frac{1}{2}\overline{\angle C+\angle B} : t, \frac{1}{2}\overline{\angle C-\angle B}$.
Or $567 : 249 :: t, 60^\circ\, 56' : Q.$

Now the extent from 567 to 249 on the numbers, being applied to the tangent, will reach from 45° to about 23° 40′: Let one point of the compaſſes reſt on this diviſion, and bring the other to 60° 56′; then this extent will reach from 45° to 38° 19′ the half difference ſought.

And this method will always give the half difference whether the half ſum of the angles is greater or leſs than 45°.

377. But when the half ſum and half diff. are greater than 45°. Then the extent from the ſum of the ſides to their diff. on the ſcale of numbers, will (on the tangents) reach from the half ſum of the angles to their half diff. reckoning from left to right.

And when the half ſum and half diff. are both leſs than 45°; then the extent from the ſum of the ſides to their diff. taken from the numbers and applied to the tangents, will reach from the half ſum of the angles downwards to their half diff.

378. When the three ſides are given to find an angle, and a perpendicular is drawn from an angle to its oppoſite ſide. See Ex. X. art. 357.

As $AC : BC+AB :: BC-AB : CD-AD$.
Or $291 : 411 :: 21 : Q.$

Now the extent from 291 to 411 on the ſcale of numbers, will reach from 21 to 29,6 alſo on the numbers.

Then the extent for the angles is performed in the ſame manner as ſhewn in Ex. I. (373)

379. Or an angle may be found by Problem VI. as follows.
In the ſcale of numbers, take the extent from the half ſum (of G & D) to either of the containing ſides (as E); apply this extent from the other containing ſide (as F), to a fourth term: Let one point of the compaſſes reſt on this fourth term, and extend the other to the half difference (of G & D); then this extent applied to the verſed ſines, from the beginning, will give the ſupplement of the angle ſought.

In Example X. See art. 357.

E = 291; F = 216; half ſum = 135; half diff. = 60.

Then on the numbers, the extent from 135 to 291, will reach from 216 to 465; let the point reſt there, and extend the other to 60; then this extent applied to the verſed ſines, will reach from the beginning to 137° 56′; which taken from 180°, leaves 42° 04′ for the angle ſought.

380. In Example XI. See art. 358.

Here E = 408; F = 351; half ſum of G & D = 108; half diff. = 51.

Then on the numbers, the extent from 108 to 408, will reach from 351 in the ſecond interval, to ſome point beyond the ſcale; therefore apply the extent in the firſt interval, which will reach from 35,1 to 132,6; let one point reſt at 132,6 and extend the other to 51: Now as this extent is leſs than it ought to be by one interval, or half the length of the ſcale of numbers; therefore the laſt extent muſt be applied, on the verſed ſines, from the point oppoſite to the middle of the ſcale of numbers, which is nearly at 143°; then it will reach from thence to 157° 23′, which taken from 180° leaves 22° 37′ for the angle ſought.

Moſt of the writers on Plane Trigonometry treat of right angled, and of oblique angled triangles ſeparately; making ſeven caſes in the former and ſix caſes in the latter: But as every one of theſe thirteen caſes fall under one or other of the foregoing Problems, therefore ſuch diſtinctions are here avoided, it being conceived that they rather tend to perplex than inſtruct a learner: Alſo in the generality of the treatiſes on this ſubject 'tis uſually ſhewn how the ſolutions of right angled triangles are performed by making (as 'tis called) each ſide radius; that is, by comparing each ſide of the triangle with the radius of the tables: And altho' theſe conſiderations are here omitted, yet the inquiſitive reader will find them in the table at article 684.

THE ELEMENTS OF NAVIGATION.

BOOK III.

OF SPHERICS.

SECTION I.

Definitions and *Principles.*

381. SPHERICS is that part of the Mathematics which treats of the poſition and menſuration of arcs of circles deſcribed on the ſurface of a ſphere.

382. A ſphere is a ſolid contained under one uniform round ſurface, ſuch as would be formed by the revolution of a circle about a diameter thereof, that diameter being immoveable during the motion of the circle.

Thus the circle AEBD *revolving about the diameter* AB, *will generate a ſphere, whoſe ſurface will be formed by the circumference* AEBD. See Plate I.

383. The centre and axis of a ſphere are the ſame as the centre and diameter of the generating circle: And as a circle has an indefinite number of diameters, ſo a ſphere may be conſidered as having alſo an indefinite number of axes, round any one of which the ſphere may be conceived to be generated.

384. Circles of the ſphere, are thoſe circles deſcribed on its ſurface, by the motion of the extremities of ſuch chords in the generating circle as are at right angles to the diameter thereof, or to the axis of the ſphere.

Thus by the motion of the circle AEBD *about the diameter* AB, *the extremities of the chords* ED, GF, IH, *at right angles to* AB, *will deſcribe circles whoſe diameters are equal to thoſe chords.* Plate I.

385. The Poles of a circle on the ſphere, are thoſe points on its ſurface equally diſtant from the circumference of that circle.

Thus A *and* B *are the poles of the circles deſcribed on the ſphere by the ends of the chords* ED, GF, IH. Plate I.

386. A great circle of the ſphere, is that circle which is equally diſtant from both its poles.

Thus the circle deſcribed by the extremities E, D, *of the diameter* ED, *at right angles to* AB, *being equally diſtant from its poles* A *and* B, *is called a great circle.*

387. Leſſer circles of the ſphere, or ſmall circles, are thoſe which are unequally diſtant from both their poles.

Thus the circles whoſe diameters are FG, HI, *having their poles* A *and* B *unequally diſtant from them, are called leſſer circles.*

388. Parallel circles of the ſphere are ſuch whoſe planes are conſidered as parallel to the plane of ſome great circle.

Thus the circles whoſe diameters are FG, HI, *are called parallel circles in reſpect to the great circle whoſe diameter is* ED.

389. A ſpheric angle is the inclination of two great circles of the ſphere meeting one another; and is meaſured by an arc of a great circle intercepted between the legs of that angle, at 90 degrees diſtant from the angular point.

390. A ſpheric triangle is a figure formed on the ſurface of a ſphere by the mutual interſections of three great circles.

391. The ſtereographic projection of the ſphere, is ſuch a repreſentation of its circles upon the plane of one of them paſſing thro' the centre, and called the plane of projection, as would appear to an eye placed in one of the poles of that great circle, and thence viewing the circles on the ſphere.

392. The place of the Eye is called the projecting point, or lower pole, and the point diametrically oppoſite is called the remoteſt, or oppoſite, or upper pole.

393. The Primitive circle is that great circle which limits or bounds the repreſentation or projection.

394. An Oblique circle is the projection of ſuch a great circle whoſe plane lies obliquely to the eye.

395. A Right circle is repreſented by a diameter of the primitive circle, and is the projection of that great circle whoſe plane paſſes thro' the eye, or is ſeen edgewiſe.

AXIOMS.

396. The diameter of every great circle paſſes thro' the centre of the ſphere; but the diameters of all ſmall circles do not paſs thro' the ſame centre: Alſo the centre of the ſphere is the common centre of all its great circles.

397. Every ſection of a ſphere by a plane, is a circle.

398. A ſphere is divided into two equal parts by the plane of every great circle; and into two unequal parts by the plane of every ſmall circle.

399. The pole of every great circle is at 90 degrees diſtance from it on the ſurface of the ſphere: And no two great circles can have a common pole.

400. The poles of a great circle are the extremities of that diameter, or axis of the ſphere which is perpendicular to the plane of that circle.

401. Lines flowing to the projecting point, or place of the eye, from every point in the circumference of a circle which it views, form the convex ſurface of a Cone.

402. The projection of any point on the ſphere, is that point in the plane of projection thro' which the viſual ray paſſes to the eye.

403. A plane paſſing thro' three points on the ſurface of a ſphere, equally diſtant from the pole of a great circle, will be parallel to the plane of that circle.

404. The ſhorteſt diſtance between two points on the ſurface of a ſphere, is the arc of a great circle paſſing thro' thoſe points.

405. If one great circle meets another, the angles on either ſide are ſupplements to one another; and every ſpheric angle is leſs than 180 degrees.

406. If two circles interſect one another, the oppoſite angles are equal.

407. Two ſpheric triangles are congruous, if two ſides and their contained angle in one, are equal to two ſides and their contained angle in the other each to each: Or if two angles and the contained ſide in the one, are equal to two angles and their contained ſide in the other each to each: Or if the three ſides in the one, are reſpectively equal to the three ſides in the other.

408. All parallel circles having the ſame pole, may be conceived to be concentric to the great circle to which they are parallel.

409. All circles on the ſphere having the ſame pole, are cut into ſimilar arcs by great circles paſſing thro' that pole.

SECTION

SECTION II.

STEREOGRAPHIC PROPOSITIONS.

410. PROPOSITION I.

Great circles of a ſphere mutually cut one another into two equal parts.

DEMONST. Any two great circles have the ſame common centre. (396)
And their planes interſect in a right line. (283)
Now the centre muſt lye in their interſection.
Therefore this right line is a diameter common to both.
But every circle is biſected by its diameter.
Therefore the circles mutually biſect one another.

411. COROL. I. Two great circles interſecting one another, twice, the angles at both ſections are equal.

For the planes of thoſe circles have the ſame inclination on either ſide of their interſection.

412. COROL. II. Two great circles of the ſphere will cut each other twice at the diſtance of 180 degrees, or in oppoſite points of this ſphere.

413. PROP. II.

The diſtance of the poles of two great circles, is equal to the angle formed by the inclination of thoſe circles. Plate I.

DEM. Let AEB, CED, be two great circles of the ſphere, their planes paſſing thro' its centre F; and let *a*, *b*, be the poles of the former, and *c*, *d*, the poles of the latter.
Then is the arc A*a* = arc C*c* = 90°. (399)
And the arc C*a* is common to both.
Therefore the arc AC meaſuring the inclination CFA of the circles, is equal to the arc *ac* meaſuring the diſtance of the poles.

414. COROL. I. Two great circles are at right angles to one another when they paſs thro' each other's poles.

415. COROL. II. The pole of a great circle is 90 degrees diſtant from it, taken in another great circle, or in an arc thereof, drawn perpendicular to the former circle.

416. COROL. III. Two or more great circles at right angles to another great circle, interſect one another at 90° diſtant from it, or in the pole of the latter circle. And the like of arcs of great circles.

417. COROL. IV. If ſeveral great circles interſect one another in the pole of another great circle; then are the former circles perpendicular to the latter.

418. PROP. III.

In the ſtereographic projection of the ſphere, the repreſentations of all circles, not paſſing thro' the projecting point, will be circles. Plate I. three figures.

Let ACEDB repreſent a ſphere, cut by a plane RS, paſſing thro' the centre I, at right angles to the diameter EH, drawn from E the place of the eye.

And let the ſection of the ſphere by the plane RS, be the circle CFDL, whoſe poles are H and E.

Suppoſe AGB is a circle on the ſphere to be projected, whoſe pole, moſt remote from the eye, is P: And the viſual rays from the circle AGB meeting in E, form the cone AGBE, whereof the triangle AEB is a ſection thro' the vertex E, and diameter of the baſe AB. (278)

Then will the figure *agbf*, which is the projection of the circle BGA, be a circle.

DEMONSTRATION. Since the ∠ E*ab* is meaſured by $\frac{1}{2}$ arc AC + ($\frac{1}{2}$ arc ED =) $\frac{1}{2}$ arc CE. (220)

And the ∠ EBA is meaſured by $\frac{1}{2}$ arc AC + $\frac{1}{2}$ arc CE. (211)

Therefore the angle EBA = angle E*ab*. (141)

And ſo the triangles EAB, E*ba*, are ſimilar, the ∠ E being common.

Therefore *ab* cuts the ſides EA, EB, of the cone in a ſubcontrary poſition to AB; and conſequently the ſection *afbg* is a circle. (286)

Now ſuppoſe the plane RS to revolve on the line CD, till it coincides with the plane of the circle ACEB.

Then 'tis evident that the point L will fall in H, the point F in E, and the circle CFDL will coincide with the circle CEDH, which now becomes the primitive circle, where the point F, or E, is the projecting point: Alſo the projected circle *afbg* will become the circle *a*N*b*K.

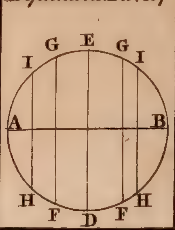
419. COROL. I. Hence the middle of the projected diameter is the centre of the projected circle, whether it be a great circle or a ſmall one.

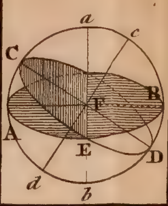
420. COROL. II. Hence in all circles parallel to the plane of projection, their centres and poles will fall in the centre of the projection.

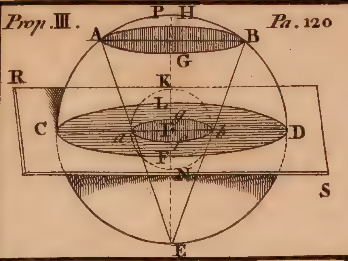
421. COROL. III. The centres and poles of circles inclined to the plane of projection, fall in that diameter of the primitive circle which is at right angles to the diameter drawn thro' the projecting point; but at different diſtances from its centre.

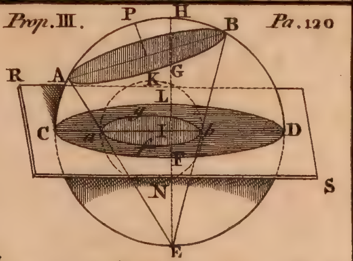
422. COROL. IV. All oblique great circles cut the primitive circle in two points diametrically oppoſite.

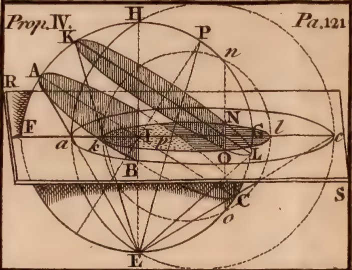
SPHERICS. Pl. I.

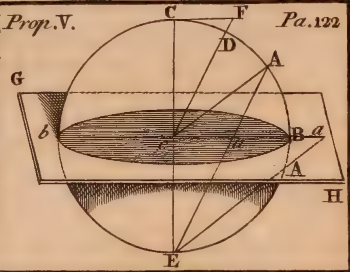

Definitions. Pa. 117

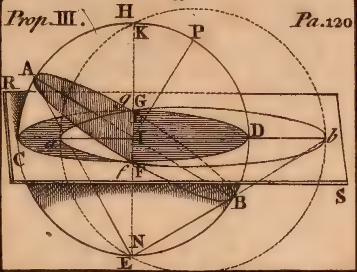

Prop. II. Pa. 119

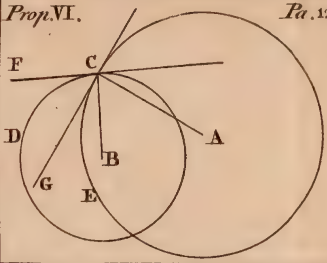

Prop. III. Pa. 120

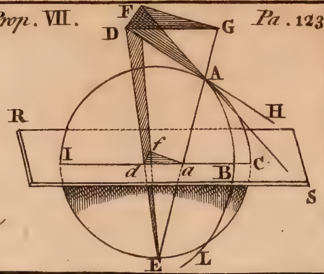

Prop. III. Pa. 120

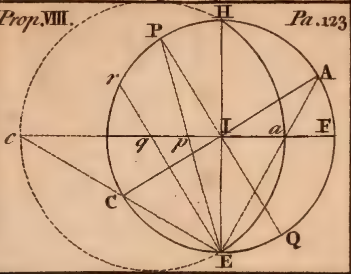

Prop. IV. Pa. 121

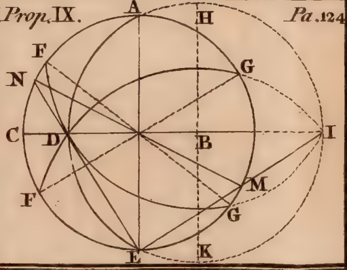

Prop. V. Pa. 122

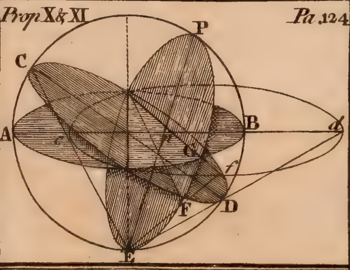

Prop. III. Pa. 120

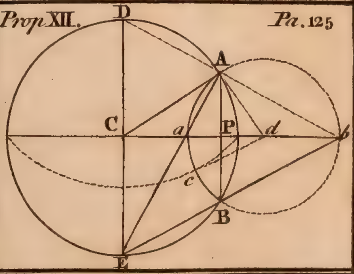

Prop. VI. Pa. 122

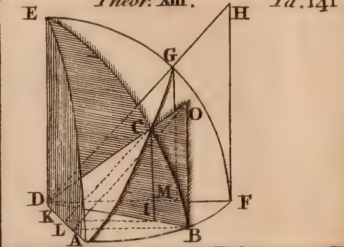

Prop. VII. Pa. 123

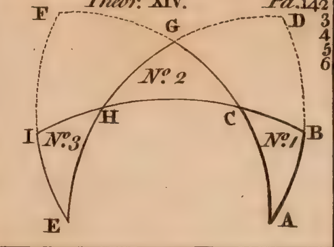

Prop. VIII. Pa. 123

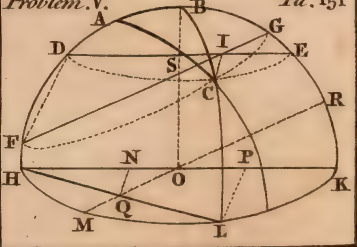

Prop. IX. Pa. 124


Prop. X & XI. Pa. 124


Prop. XII. Pa. 125


Theor. XIII. Pa. 141


Theor. XIV. Pa. 142


Problem. V. Pa. 151

T. Jefferys sculp.

against page 152

423. PROP. IV.

The projected diameter of any circle ſubtends an angle at the eye equal to the diſtance of that circle from its neareſt pole, taken on the ſphere. And that angle is biſected by a right line joining the eye and that pole. Plate I.

Let the plane RS cut the ſphere HFEG as in the laſt.
And let ABC be any oblique great circle, whoſe diameter AC is projected in ac; and KOL any ſmall circle parallel to ABC, whoſe diameter KL is projected in kl.

The diſtances of thoſe circles from their pole P, being the arcs AHP, KHP, and the angles aEc, kEl, are angles at the eye ſubtended by their projected diameters ac, kl.

Then is the angle aEc meaſured by the arc AHP, the angle kEl is meaſured by the arc KHP; and thoſe angles are biſected by EP.

DEM. For arc PHA = arc PC; and arc PHK = arc PL. (385)
And the ∠ AEC is meaſured by $\frac{1}{2}$ arc APC = arc PHA. (220)
Alſo the ∠ KEL is meaſured by $\frac{1}{2}$ arc KPL = arc PHK. (220)
Therefore the angles AEC, KEL, are reſpectively meaſured by the arcs PHA, PHK.
And 'tis evident thoſe angles are biſected by the line EP.

424. COROL. I. Hence as the line EP projects the pole P in p; ſo the ſame line refers a projected pole to its place on the ſphere, in the circumference of the primitive circle.

425. COROL. II. Hence on the primitive circle may be deſcribed the repreſentation of any circle whoſe diſtance from its pole, and the projected place of that pole are given.

For PA and PC are projected into pa and pc; and the biſection of ac gives the centre of the circle ſought.

426. COROL. III, Hence every projected oblique great circle cuts the primitive circle in an angle equal to the inclination of the plane of that oblique circle to the plane of projection.
For Fa is equivalent to FA the inclination.
And Fa meaſures the angle FHa, ſince FH, Ha are each 90°. (389)

427. COROL. IV. The diſtance between the projections of a great circle and any of its parallels is equivalent to their diſtance on the ſphere.
Thus the projection ak is equivalent to AK.

428. PROP. V.

Any point of a ſphere ſtereographically projected, is diſtant from the centre of projection, by the tangent of half the arc intercepted between that point and the pole oppoſite to the eye: The ſemidiameter of the ſphere being made radius. Plate I.

Let C *b* EB be a great circle of the ſphere whoſe centre is *c*, GH the plane of projection cutting the diameter of the ſphere in *b*, B; E, C, the poles of the ſection by that plane; and *a* the projection of A.
Then is *c a* equal to the tangent of half the arc AC.

DEM. Draw CF, a tangent to the arc CD = $\frac{1}{2}$ arc CA, and join *c* F.
Now the triangles CF *c*, *c a* E, are congruous: For C *c* = *c* E, ∠ C = ∠ E *c a* = right ∠, ∠ C *c* F = ∠ *c* E *a*: Therefore *c a* = CF.
Conſequently *c a* is equal to the tangent of half the arc CA.

429. PROP. VI.

The angle made by the interſection of the circumferences of two circles in the ſame plane, is equal to the angle made by tangents to thoſe circles in the point of ſection; and alſo is equal to the angle made by their radii drawn to that point. Plate I.

Let CE, CD, be two arcs of circles in the ſame plane cutting in the point C; AC, BC, their radii; GC, FC, tangents at the point C.
Then is the curve lined angle ECD = ∠ GCF = ∠ ACB.

DEM. Since the radii AC, BC, are at right angles to their tangents GC, FC (209); and are alſo at right angles to the arcs CE, CD. (219)
Therefore the poſition of the tangents and arcs at the point C are the ſame; and therefore the ∠ ECD = ∠ GCF.
Alſo the ∠ ACB + ∠ BCG = (right ∠ =) ∠ FCG + ∠ BCG.
Therefore the angle ACB is equal to the angle FCG, by taking away the common angle BCG.
Conſequently ∠ ECD = ∠ GCF = ∠ ACB.

430. SCHOLIUM. If the arcs CE, CD, were in different planes, the ſame would hold true with regard to their tangents.

For ſuppoſe the circle CD to revolve on the fixed radius BC, ſtill cutting the circle CE in C: Then the tangent CF revolving with it, has ſtill the ſame inclination to BC: And as the inclination of the planes of the circles vary, ſo much will the inclination of the tangents vary.

Therefore the angle made by the tangents, in all poſitions of the circular planes, is the ſame as the angle made by their circumferences.

431. COROL. Hence if a plane touch a ſphere, at the point where two circles thereof interſect one another, the tangents to both circles will lie in that plane; and conſequently, in all oblique poſitions, a right line perpendicular to one tangent will cut the other tangent.

432. PROP. VII.

The angle which any two circles make when ſtereographically projected, is equal to the angle which thoſe circles make on the ſphere. Plate I.

Let IACE and ABL be two circles on a ſphere interſecting in A; E the projecting point, and RS the plane of projection whereon the point A is projected in a, in the line IC, the diameter of the circle ACE.

Alſo let DH, FA, be tangents to the circles ACE, ABL.

Then if ad, af, are the projections of the tangents AD, AF; the projected $\angle daf$ will be equal to the ſpheric angle BAC.

DEM. As the tangents AD, AF, are obliquely poſited in a plane touching the ſphere in A. (431)

From any point D in the tangent AD, draw DF perpendicular to AD meeting the tangent AF in F; draw DG parallel to IC meeting EA produced in G, and draw FE cutting the plane of projection in f.

Now as the tangent DH is in the ſame plane with the circle ACE paſſing thro' the eye E, the line AD will be projected in the line ad.

And as $\angle \mathrm{DGE} = \angle da\mathrm{E}$ (185) $= \angle \mathrm{EAH}$. (215, 220)

And $\angle \mathrm{EAH} = \angle \mathrm{DAG}$. (183)

Therefore $\angle \mathrm{DGE} = \angle \mathrm{DAG}$. And $\mathrm{DG} = \mathrm{DA}$. (194)

Alſo DF being perpendicular to AD, is at right angles to the plane ACE; and conſequently is in a parallel poſition to the plane RS.

Therefore df the projection of DF is at right angles to da the projection of DA.

Therefore the triangles dfa, DFG, are parallel ſections of the pyramid DFGE: So that $ad : df :: (\mathrm{DG} =)\ \mathrm{DA} : \mathrm{DF}$. (285)

Now the triangles ADF, adf, having an equal angle in each, and the ſides about that angle proportional, are ſimilar. (251)

Conſequently the angle $daf =$ angle DAF.

But $\angle \mathrm{DAF} = \angle \mathrm{BAC}$ (429): Therefore $\angle daf = \angle \mathrm{BAC}$.

433. PROP. VIII.

The diſtance between the poles of the primitive circle and an oblique circle, in ſtereographic projections, is equal to the tangent of half the inclination of thoſe circles; and the diſtance of their centres is equal to the tangent of their inclination: The ſemidiameter of the primitive circle being made radius. Plate I.

Let AC be the diameter of a circle whoſe poles are P and Q, and inclined to the plane of projection in the angle AIF.

And let a, c, p, be the projections of the points A, C, P.

Alſo let $\mathrm{H}a\mathrm{E}$ be the projected oblique circle, whoſe centre is q.

Now when the plane of projection becomes the prim. circle whoſe pole is I.

Then is $\mathrm{I}p =$ tangent of half $\angle \mathrm{AIF}$, or of half the arc AF.

And $\mathrm{I}q =$ tangent of AF, or of the $\angle \mathrm{FH}a = \mathrm{AIF}$.

DEM. For $\mathrm{AH} + \mathrm{HP} = \mathrm{AH} + \mathrm{AF}$. Therefore $\mathrm{HP} = \mathrm{AF}$.

But $\mathrm{I}p =$ tangent of half HP, or of half AF. (428)

Again. As AC is projected in ac, then q the middle of ac, is the centre of the projected circle, and of its repreſentative $\mathrm{H}a\mathrm{E}$. (425)

Draw $\mathrm{E}q$ produced to r: Then as $qa = q\mathrm{E}$; the $\angle q\mathrm{E}a = \angle qa\mathrm{E}$. (194)

But the $\angle qaE$ is meaſured by half the arc EFA. (220)
Therefore the arc $AHr =$ arc AFE (143): And as the arc $AHP = FQE$.
Therefore $Pr = AF = HP$; and $HPr =$ twice the arc AF.
Therefore (210) the $\angle IEq = \angle AIF$, the inclination of the circles.
But Iq is the tangent of the $\angle IEq$, EI being the radius.

434. Corol. Hence the radius of an oblique circle is equal to the ſecant of the obliquity of that circle to the primitive.
For Eq is the ſecant of the angle IEq, to the radius EI.

435. PROP. IX.

If thro' any given point in the primitive circle an oblique circle be deſcribed; then the centres of all other oblique circles paſſing thro' that point, will be in a right line drawn thro' the centre of the firſt oblique circle at right angles to a line paſſing thro' that centre, the given point, and the centre of the primitive.

Let GACE be the primitive circle, ADEI a great circle deſcribed thro' D, its centre being B.

HK is a right line drawn thro' B, perpendicular to a right line CI paſſing thro' D, B, and the centre of the primitive circle.

Then the centres of all other great circles FDG paſſing thro' D will fall in the line HK.

Dem. For if E be the projecting point, the circle EDAI will be the projection of a circle whoſe diameter is NM. (418)

Therefore D and I are the projections of N, M, which are oppoſite points on the ſphere; or of points at a ſemicircle's diſtance.

Therefore all circles paſſing thro' D and I muſt be the projections of great circles on the ſphere.

But DI is a chord in every circle paſſing thro' the points D, I.

Conſequently the centres of all thoſe circles will be found in HK drawn perpendicularly thro' B the middle of DI. (208)

436. PROP. X.

Equal arcs of any two great circles of the ſphere, will be intercepted between two other circles drawn on the ſphere thro' the remoteſt poles of thoſe great circles. Plate I.

Let PBEA be a ſphere, whereon AGB, CFD, are two great circles, whoſe remoteſt poles are E, P; and thro' theſe poles let the great circle PBEC, and ſmall circle PGE, be drawn. interſecting the great circles AGB, CFD, in the points B, G, and D, F.
Then are the intercepted arcs BG and DF equal to one another.

Dem. For the arcs $ED + DB =$ arcs $PB + DB$; therefore $ED = PB$.
And the arcs $EF + FG =$ arcs $PG + FG$ (399); therefore $EF = PG$.
For the points F and G are equally diſtant from their poles P, E.
Alſo the $\angle DEF = BPG$; for interſecting circles make equal angles at the ſections. (411)
Therefore the triangles EFD and PGB are congruous. (407)
Therefore the arc $BG =$ arc DF.

437.
PROP. XI.

If lines be drawn from the projected pole of any great circle, cutting the peripheries of the projected circle and plane of projection, the intercepted arcs of thoſe circumferences are equal. Plate I.

On the plane of projection AGB, let the great circle CFD be projected in *cfd*, and its pole P in *p*: Then the lines *pd*, *pf*, being drawn, cutting the circumference of the plane of projection in B, G, and that of the projected circle in *d*, *f*; the arc GB = arc *fd*.

Dem. For as the points D, F, are projected in *d*, *f*. (418)
The arc *fd* is equivalent to the arc FD.
But the arc FD is equal to the arc GB. (435)
Therefore the arc GB is equal to the arc *fd*.

438.
PROP. XII.

The radius of any ſmall circle, whoſe plane is perpendicular to that of the primitive circle, is equal to the tangent of that leſſer circle's diſtance from its pole; and the ſecant of that diſtance, is equal to the diſtance of the centres of the primitive and leſſer circle. Plate I.

Let P be the pole, and AB the diameter of a leſſer circle, the plane being perpendicular to the plane of the primitive circle, whoſe centre is C: Then *d* being the centre of the projected leſſer circle, *d*A is equal to the tangent of the arc PA, and *d*C = ſecant of PA.

Dem. Draw the diameter ED parallel to AB, and thro' P draw C*b*. Now
E being the projecting point, the diameter AB is projected in *ab*. (402)
And *d* the middle of *ab* is the centre of a circle on *ab*. (419)
Then a right line drawn from D thro' A, will meet *b*: (213)
And draw CA, *d*A.
Now the right angled triangles DC*b*, DAE, having the angle D common;
the ∠D*b*C = ∠DEA. (188)
But ∠DEA = $\frac{1}{2}$ ∠DCA; and ∠D*b*C = $\frac{1}{2}$ ∠A*d*C: (210)
Therefore ∠DCA = ∠A*d*C.
Now ∠DCA + ∠AC*d* = right angle;
Then ∠A*d*C + ∠ACD = right angle: Therefore ∠CA*d* is right (186)
Conſequently *d*A = radius of the circle A*a*B, is the tangent of
the arc PA, to the radius CA. (209)
And *d*C, the diſtance of the centres, is the ſecant of the arc AB. (300)

439. Corol. Hence the tangent and ſecant of any arc of the primitive circle, belongs alſo to an equal arc of any oblique circle; thoſe arcs being reckoned from their interſection.

For the arc P*c* of every oblique circle intercepted between P and the arc of the ſmall circle A*a*B, is equivalent to the arc PA of the primitive circle: Becauſe the arc A*a*B is equally diſtant from its pole P. (385)

SECTION

SECTION III.

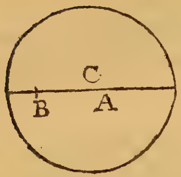
SPHERICAL GEOMETRY.

Spheric Geometry, or ſpheric projection, is the art of deſcribin or repreſenting on the plane of a great circle, ſuch circles or arcs o circles as are uſually drawn upon a ſphere; and of meaſuring ſuch arc and their poſitions to one another when projected.

440. PROBLEM I.

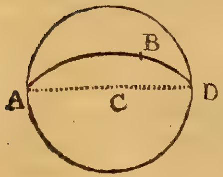
To deſcribe a great circle that ſhall paſs thro' two given points in the pri mitive circle, or plane of projection.

Let the given points be A, B; and C the centre of the prim. circle.



CASE 1. *When one point* A *is the centre of the pr mitive circle.*

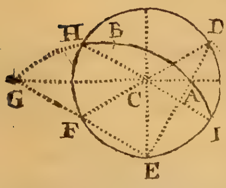
CONST. A diameter drawn thro' the given poin A, B, will be the great circle required. (39



CASE 2. *When one point* A *is in the circumf. of t primitive circle.*

CONST. Thro' A draw a diameter AD.

Then an oblique circle deſcribed thro' the thr points A, B, D, (163) will be the great circle r quired. (42



441. CASE 3. *When neither point is at the centr or circumference of the primitive circle.*

CONST. Thro' one point A, and the centre draw AG, and draw CE at right angles to AG.

A ruler by E and A gives D; by D and C gives and by E and F gives G, in AC continued.

Thro' the three points G, B, A, deſcribe a circumference (163) cutti the primitive circle in H and I.

Then the oblique circle HBAI will be the great circle required.

For AG may be taken as the projection of the great circle FD. (40

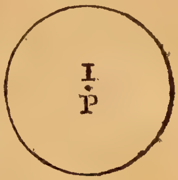
Therefore A and G are the projections of oppoſite points on t ſphere. (41

Conſequently all circles paſſing thro' G and A will be the repreſent tives of great circles on the ſphere.

42. PROBLEM II.

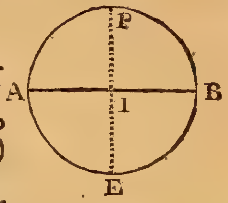
About any given point as a pole, to deſcribe a great circle in a given primi-ive circle.

Let P be the given point, and I the centre of the primitive circle.



Case 1. *When the given pole* P *is in the centre of the rimitive circle.*

Const. The primitive circle will be the great ircle required. (393)

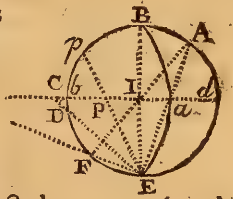


Case 2. *When the given pole* P *is in the circumfe-ence of the primitive circle.*

Const. Thro' the given pole P, draw PE a dia-ıeter to the primitive circle.
Then another diam. AB, drawn at right angles to E, will be the great circle required. (400, 395)

443. Case 3. *When the given pole* P *is neither in e centre or circumference of the primitive circle.*

Const. Thro' P draw a diameter bd, and another BE at right an-les to bd; then a ruler by E and P gives p.

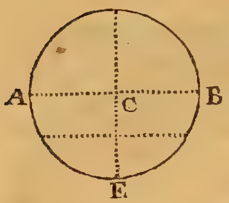


Make the arc $pA = 90°$; a ruler by E and A gives in the diam. bd.
Make the arc $pD =$ arc pB; a ruler on E and D ives C in db produced.
Then on C with the radius Ca deſcribe BaE.
For, As E is the projecting point, and P the pro-cted pole;
Therefore p is the pole of the circle AF to be projected. (424)
And BaE is the projection of the circle AF. (418)
Now $\angle CaE$ is meaſured by half the arc AdE. (220)
But arc $ABD =$ arc AdE: For $Ap = (Bd =)\ dE$; and $pD = Ad$ y conſt.
Therefore $\angle AEC = \angle CaE$; and $CE = Ca$. (194)
Conſequently C is the centre required.

444.

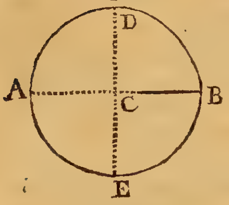
444. PROBLEM III.

A projected circle being given, to find its poles.



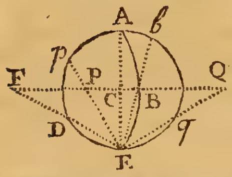
Case 1. *When the given circle* AEB *is the primitive.*

Const. Find the centre C, (161) and it is the pole ſought.



Case 2. *When the given circle* ACB *is a right circle.*

Const. Draw a diameter ED at right angles to AB, and the ends or points D, E, of that diameter are the poles required.



445. Case 3. *When the given circle* ABE *is oblique*

Const. Thro' the interſections of the primitive and oblique circles draw a diameter AE, and another at right angles to AE, cutting the given oblique circle in B.

A ruler by E and B gives b; make $b\,p$, $b\,q$, each = chord of 90°.

A ruler by E and p gives, in the diameter thro' B, the point P, which is the pole required.

And a ruler by E and q gives, in CB continued, the point Q for the other, or oppoſite or exterior pole.

Make p D = p A; then a ruler by E and D gives, in BC continued, the point F which is the centre of the oblique circle ABE.

The reaſon of this operation is evident from that of the laſt Prob.

446. PROBLEM IV.

To meaſure any arc of a projected great circle: Or in a given projected great circle to take an arc of a given number of degrees.

General Solution. Find the pole of the given circle. (444)

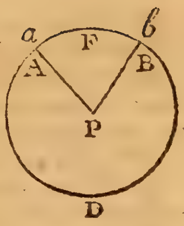
From that pole draw lines thro' the ends of the propoſed arc, cutting the primitive circle.

Then the intercepted arc of the primitive circle applied to the ſcale of chords will give the meaſure ſought.

Thus, If AB be the arc to be meaſured, and P the pole of the given circle DAF.

Then lines drawn from P thro' A and B, gives the arc $a\,b$ in the primitive circle, correſponding to AB in the projected circle.

Now

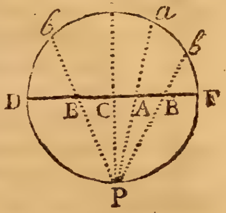


Now if an arc of a given number of degrees was to be taken from a given point A, in the given projected circle DAF.

Draw from the pole P thro' A, the line P *a* to the primitive circle.

Apply the given number of degrees from *a* to *b*.

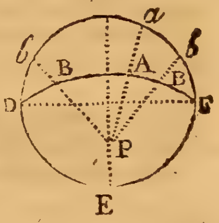
Draw P *b*, and the intercepted arc AB will contain the degrees propoſed.



447. Any number of degrees are readily applied to a right circle by the ſcale of half tangents. Thus,

When the diſtance of the point A from the centre C is known, and the given quantity of the arc is to be laid from A towards F.

To the known diſtance CA add the propoſed arc AB, the degrees in the ſum taken from the ſcale of half tangents and laid from C to B, will make the arc AB equal to the degrees propoſed.



But when the arc AB is to be laid from A towards D,

Then the difference between the arcs AB and AC aken from the ſcale of half tangents and laid towards from C to B will make the arc AB equal to the degrees propoſed.

The reaſon of all theſe operations is evident rom art. 437.

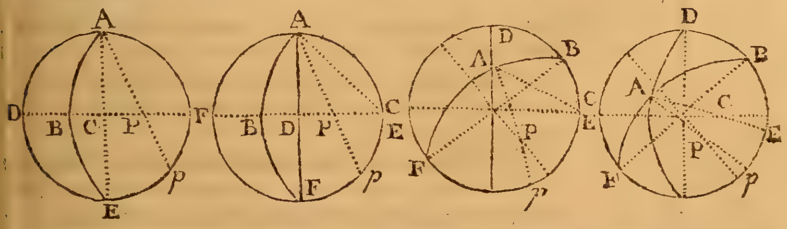
Note. The half, or ſemi-tangents are only the tangents of half the rcs the ſcale of tangents is made to; their conſtruction depends on art. 428. n the *plane ſcale* they are put under the Tangents, and marked S. T.

448. PROBLEM V.

To meaſure any projected ſpherical angle.

General Solution. Find the poles of the two circles which form he angle; and from the angular point draw lines thro' thoſe poles to cut he primitive circle.

Then the meaſure of that angle, if acute, will be the intercepted arc f the primitive circle; or the ſupplement of that arc will be the meaure of the angle when obtuſe.



Let the propoſed angle be DAB, formed by the great circles AD, AB, hoſe poles are C and P; and lines drawn from the angular point A thro' e poles C and P cut the primitive circle in E and *p*.

1ſt. When the angle is formed by the primitive and oblique circles.

Then the arc *p* E meaſures the acute angle DAB.

But the obtuſe angle BAF is meaſured by the ſuppl. of *p* E.

2d. When the angle is formed by right and oblique circles meeting in the primitive's circumference.

Then the arc *p* E meaſures the angle DAB.

3d When the angle is formed by right and oblique circles meeting within the primitive circle.

Then the arc *p* E meaſures the acute angle DAB.

But the obtuſe angle DAF is meaſured by the ſupplement of *p* E.

4th. When the angle is formed by two oblique circles meeting within the primitive circle.

Then the acute angle DAB is meaſured by the arc *p* E.

But the ſupplement of *p* E meaſures the obtuſe angle DAF.

For, As the angular point A is in both circles, and 90° diſtant from their poles C and P (399). Therefore a great circle deſcribed about A as a pole, will paſs thro' the poles C and P.

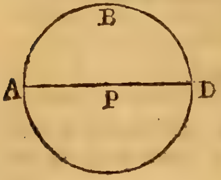
And lines drawn from A thro' C and B, cut off, in the circumference of the plane of projection, an arc equal to the diſtance of the poles C and P. (437)

But the meaſure of the diſtance of the poles C, P, is equal to the inclination of the planes of the circles AD, AB; (413)

And conſequently meaſures the angle DAB.

449. PROBLEM VI.

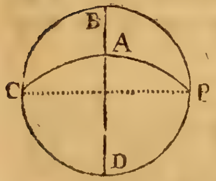
Thro' a given point in any projected great circle, to deſcribe another great circle at right angles to the given one.



GENERAL SOLUTION. Find the pole of the given circle.

Then a great circle deſcribed thro' that pole and the given point will be at right angles to the given circle.

Let the given projected great circle be BAD; and A the given point.

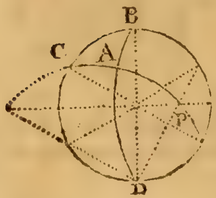


1ſt. *When* BAD *is the primitive circle whoſe pole is* P

A diam. thro' A will be perpendicular to BAD. (219

2d. *When* BAD *is a right circle, whoſe poles are* *and* C.

An oblique circle deſcribed thro' the points C, A P, (163) will be at right angles to BAD.



3d. *When* BAD *is an oblique circle, whoſe pole is* P.

Thro' the points P and A, a great circle PAC bein deſcribed (441) will be at right angles to BAD.

The truth of theſe operations are evident from art. 414.

450

450.
PROBLEM VII.

Thro' any aſſigned point in a given projected great circle, to deſcribe another great circle cutting the former in an angle of a given number of degrees.

Let P be a given point in any great circle APB.

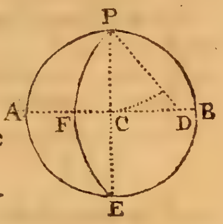
1ſt. *When* APB *is the primitive circle.*

Thro' the given point P draw a diameter PE, and draw the diameter AB at right angles to PE.

Draw PD cutting AB in D, ſo that the angle CPD be equal to the angle propoſed.

On D with the radius DP deſcribe the great circle PFE,

Then will the angle APF contain the given degrees.



FOR the ∠ FPA = angle made by the radii PC, PD. (429)

And D being equally diſtant from P and E, is the centre ſought.

451. Or thus. Make CD equal to the tangent of the given angle to the radius CP.

Or. Make PD equal to the ſecant of that angle.

452. 2d, *When* APB *is a right circle.*

Draw a diameter GH at right angles to APB.

Then a ruler by G and P gives *a* in the primitive circle.

Make $Hb = 2Aa$; a ruler by G and *b* gives C in AB.

Draw CD at right angles to AB.

Draw PD cutting CD in D, ſo that the ∠ CPD = comp. of the deg. given. (175)

On D with the radius DP deſcribe a circle FPE; which will be a great circle making with APB the angle APF as required.

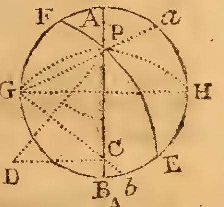
FOR, C is the centre of a great circle GPH. (445)

And the centres of all great circles thro' P, will be in CD. (435)

Now ∠ DPE = 90°. (219)

Therefore ∠ APF = ∠ BPE (406) = comp. CPD is the angle ſought.

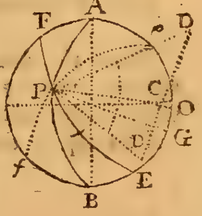
453. 3d. *When* APB *is an oblique circle.*



From the given point P, draw the lines PG, PC, thro' the centres of the primitive and given oblique circles.

Thro' C the centre of APB draw CD at right angles to PG. (150)

Draw PD, making the ∠ CPD = given deg. and cutting CD in D. (175)



From D with the radius DP, a circle FPE being deſcribed will be a great circle cutting APB in the angle propoſed.

FOR, C the centre of APD, is in a line perpendicular to PG drawn thro' P and the centre of the primitive, by conſtruction.

And the centres of all great circles thro' P will be in CD. (435)

Now the ∠ CPD made by the radii PC, PD, contains the given degrees.

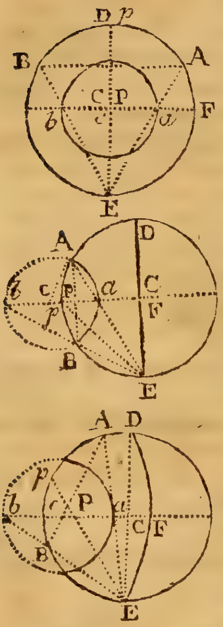
Therefore the angle APF is equal to the angle required. (429)

454. PROBLEM VIII.

About any given projected pole, to deſcribe a circle at a given diſtance from hat pole.

Or, at a propoſed diſtance from a given great circle, to deſcribe a parallel circle.

Let P be the given pole, belonging to the given great circle DFE.



General Solution. Thro' the given pole P and the centre C of the primitive circle, draw a diameter, and another DE at right angles to it.

A ruler on E and P gives p in the primitive circle.

Make p A $=p$ B, equal to the propoſed diſtance from the pole.

A ruler on E and A, E and B, will cut the diameter CP in a and b.

Biſect ab in c; and on c as a centre deſcribe a circle paſſing thro' a and b, which will be the circle required.

But when the parallel circle is to be at a propoſed diſtance from the given great circle DFE.

Find p as before; and make p A $=p$ B equal to the complement of the propoſed diſtance; the reſt as above.

For p is the pole whoſe projection is P. (424)

But p is the pole of a circle whoſe diameter AB is projected in ab. (402)

Therefore c, the middle of ab, is the centre of the projected circle. (419)

455. The firſt caſe is readily done, by deſcribing the ſmall circle about the centre of the primitive circle with the tangent of half its diſtance from the pole P.

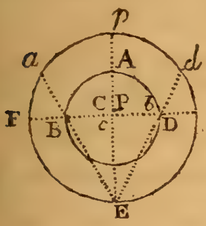
456. The ſecond caſe is ſooneſt performed thus.

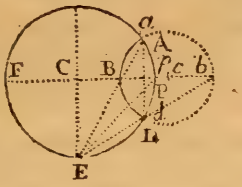
From the points A, B, (found as above), with the tangent of thei diſtance, from P the pole of the right circle, deſcribe arcs cutting in c, which is the centre of a ſmall circle parallel to the right circle DFE.

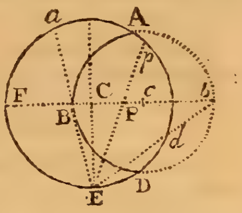
For Ap is the tangent of the arc AP. (438

457. PROBLEM IX.

The primitive circle, and the projection of a ſmall circle being given; to find the pole of that ſmall circle.







Let C be the centre of the primitive circle, and ABD a projected ſmall circle, whoſe centre is *c*, and radius *c* B.

General Solution. Thro' *c* the centre of the ſmall circle and C the centre of the primitive, draw a diameter CF, and another CE at right angles to it.

Find the projected diameter B *b* = 2 *c* B.

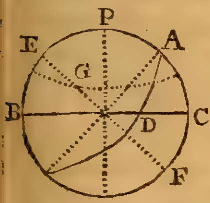
Lines drawn from E thro' B and *b*, cut the primitive circle in *a*, *d*; then biſect the arc *a d* in *p*.

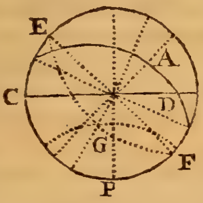
A ruler by E and *p* cuts the diameter B *b* in P, the pole ſought.

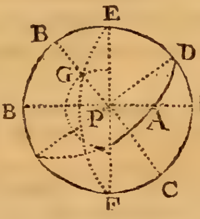
The truth of this conſtruction is evident from the laſt.

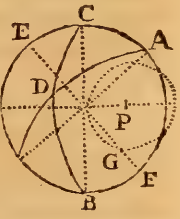
458. PROBLEM X.

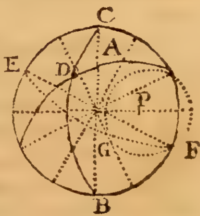
Thro' any point in the plane of projection, or primitive circle, to deſcribe a great circle that ſhall cut a given great circle in any angle propoſed: Provided the meaſure of that propoſed angle is not leſs than the diſtance between the given point and circle.











Let the given point be A, thro' which a circle is to be deſcribed to cut a given great circle BDC, whoſe pole is P, in an angle equal to a propoſed number of degrees.

General Solution. About the given point (A) as a pole, deſcribe a great circle EGF. (442)

About (P) the pole of the given circle BDC, deſcribe a ſmall circle at a diſtance equal to the given angle, cutting the great circle EGF in G. (454)

About the point G as a pole, deſcribe a great circle cutting the given circle BDC in D. Then will ADC be the angle required.

Note. When the given angle is equal to the diſtance between the given point and circle, the problem is limited; when the meaſure of the angle is greater, the problem has two ſolutions by the circle deſcribed cutting the given one in two points: But when the meaſure of the angle is leſs, the problem is impoſſible. This conſtruction is thus proved.

For P and G are the poles of BC and AD.

And the diſtance of P and G is equal to the degrees in the propoſed angle, by conſtruction. But ∠ ADC = diſtance of P and G. (413)

Therefore the ∠ ADC is the angle required.

459. *When the required circle is to make a given angle with the primitive.*

Then, From the centre of the primitive, with the tang. of the given angle, deſcribe an arc; and from the given point A, with the ſecant of the given angle, cut the former arc.

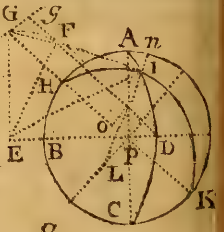
On this interſection, a circle being deſcribed thro' the given point A, will cut the primitive circle in the angle propoſed.

This depends on art. 451.

460. PROBLEM XI.

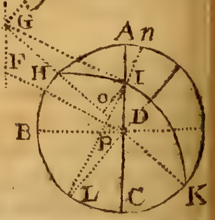
Any great circle, cutting the primitive, being given; to deſcribe another great circle, which ſhall cut the given one in a propoſed angle, and have a given arc intercepted between the primitive and given circles.

Let ABC be the primitive circle whoſe centre is P; and the given great circle be ADC whoſe centre is E.



Solution. Draw a diameter EBD at right angles to ADC; and make the angle BDF equal to the complement of the given angle; ſuppoſe = comp. of 35°. (175)

Make DF equal to the tangent of the given arc (ſuppoſe 58°); and from P with the ſecant of that arc, deſcribe an arc G*g*.



Now when ADC is an oblique circle; From E the centre of ADC, with the radius EF, cut the arc G*g* in G.

But when ADC is a right circle; Thro' F draw FG parallel to ADC cutting the arc G*g* in G: The centre E of ADC being vaſtly diſtant.

From G, with the tangent DF, deſcribe an arc *n o*, cutting ADC in I; and draw GI.

Thro' G and the centre P draw GK, cutting the primitive circle in H, K; draw PL perpendicular to GK; and IL at right angles to IG, cutting PL in L.

An

And L will be the centre of a circle paſſing thro' H, I, K, which will be the great circle required.

Then the ∠ AIH = 35°; and arc IH = 58°, as was propoſed.

For GP is the ſecant, and GI is the tang. of the arc HI. (439)

And as the triangles EGI, EFD, are congruous; the ∠ EIG = ∠ EDF. (191)

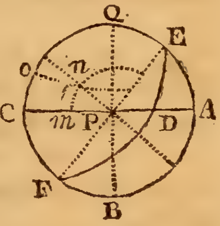
But the ∠ EIG made by the tangent of the arc HI and the radius of rc AI, is the complement of the angle made by thoſe arcs. (429)

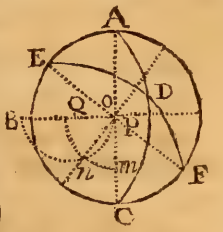
Conſequently the ∠ AIH is the complement of ∠ EDF.

61. PROBLEM XII.

Any great circle in the plane of projection being given; to deſcribe another reat circle, which ſhall make given angles with the primitive and given ircles.

Let the given great circle be ADC, whoſe pole is Q.





Solution. About P the pole of the primitive cirle, deſcribe an arc *m n*, at the diſtance of as many egrees, as are in the angle which the required circle s to make with the primitive. Suppoſe 62°. (455)

About Q the pole of the other given circle, and at diſtance equal to the meaſure of the angle which he required circle is to make with the given circle DC (ſuppoſe 48°), deſcribe an arc *o n*, cutting *m n* n *n*. (456)

About *n* as a pole, deſcribe the great circle EDF, utting the given circles in E and D. (442)

Then is the angle AED = 62°; and ∠ ADE = 48°.

For the diſtance of the poles of any two great ircles, is equal to the angle which thoſe circles make vith one another. (413)

SECTION

SECTION IV.

SPHERICAL TRIGONOMETRY.

Definitions and Principles.

462. I. Spheric Trigonometry is the art of computing the meaſures of the ſides and angles of ſuch triangles as are formed on the ſurface of a ſphere, by the mutual interſections of three great circles deſcribed thereon.

463. II. A ſpheric triangle conſiſts of three ſides and three angles.

The meaſures of unknown ſides or angles of ſpheric triangles, are eſtimated by the relations between the ſines, or the tangents, or the ſecants, of the ſides or angles known, and of thoſe that are unknown.

464. III. A right angled ſpheric triangle has one right angle: The ſides about the right angle are called Legs; and the ſide oppoſite to the right angle is called the Hypothenuſe.

465. IV. A Quadrantal ſpheric triangle has one ſide equal to ninety degrees.

466. V. An Oblique ſpheric triangle has all its angles oblique.

467. VI. The circular parts of a triangle, are the arcs which meaſure its ſides and angles.

468. VII. Two ſpheric triangles are ſaid to be ſupplements to one another, when the ſides and angles of the one are reſpective ſupplements of the angles and ſides of the other: And one, in regard to the other, is called the ſupplemental triangle.

469. VIII. Two arcs or angles, when compared together, are ſaid to be alike, or of the ſame kind, when both are acute, or leſs than 90°, or when both are obtuſe, or greater than 90°: But when one is greater and the other leſs than 90°, they are ſaid to be unlike.

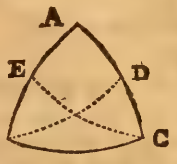
The leſſer circles of the ſphere do not enter into Trigonometrical computations, becauſe of the diverſity of their radii.

SECTION V.

SPHERICAL THEOREMS.

470. THEOREM I.

In every ſpheric triangle (ABC), *equal angles* (B, C) *are oppoſite to equal ſides* (AC, AB): *And equal ſides* (AB, AC) *are oppoſite to equal angles* (C, B).



DEM. Since AB = AC, make AE = AD; and draw BD, CE.

Then is BD = CE; and ∠ AEC = ∠ ADB. (407)

For the triangles AEC, ADB, are congruous,

Since AB = AC; AD = AE; ∠ A common.

Alſo, the triangles BEC, CDB, are congruous (407).

Therefore ∠ EBC = ∠ DCB.

For EC = BD; EB = (AB − AE =) DC (= AC − AD). (139)

And ∠ BEC = (ſup. ∠ AEC =) ∠ CDB (= ſup. ∠ ADB).

AGAIN, if ∠ ABC = ∠ ACB: Then is AB = AC.

For take BE = CD; and deſcribe the arcs CE, BD.

Then is EC = DB; ∠ BEC = ∠ CDB; ∠ BCE = ∠ CBD. (407)

For △ * BCE = △ CBD; ſince BC is common, BE = CD, ∠ EBC = ∠ DCB.

Alſo the triangles ABD, ACE, are congruous.

Since EC = BD, ∠ ACE = (∠ BCA − BCE =) (139) ∠ ABD (= ∠ CBA − CBD).

And ∠ AEC = (ſup. ∠ BEC =) ∠ ADB (= ſup. ∠ CDB.) (139)

Therefore AE = AD; and AB = (AE + EB =) AC (= AD + DC). (138)

471. COR. A line drawn from the vertex of an iſoſceles ſpheric triangle perpendicular to the baſe, will biſect that baſe.

This is eaſily proved from art. 470, 407.

72. THEOREM II.

Either ſide of a ſpheric triangle is leſs than the ſum of the other two ſides.

DEM. For on the ſurface of a ſphere, the ſhorteſt diſtance between two points, is an arc of a great circle paſſing thro' thoſe points. (404)

But each ſide of a ſpheric triangle is an arc of a great circle. (390)

Therefore either ſide being the ſhorteſt diſtance between its extremities, leſs than the ſum of the other two ſides.

73. THEOREM III.

Each ſide of a ſpheric triangle is leſs than a ſemicircle, or 180 *degrees.*

DEM. Two great circles interſect each other twice at the diſtance of 180 degrees. (412)

The ſides about any ſpheric angle are the arcs of two great circles. (390)

But a ſpheric triangle has three ſides.

Therefore every two ſides before their ſecond meeting muſt be interſected by the third ſide.

Conſequently each ſide is leſs than a ſemicircle.

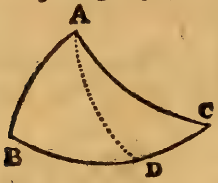
---

* The mark △ ſtands for the word triangle.

474.

THEOREM IV.

In every ſpheric triangle (ABC) *the greateſt ſide* (BC) *is oppoſite to the greateſt angle* (A).

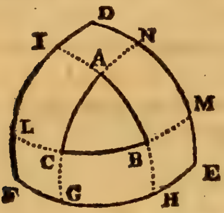


DEM. Make ∠ BAD = ∠ ABC.
Then AD = BD (470); and BC = AD + DC.
But AD + DC is greater than AC. (471)
Therefore BC is greater than AC.

475.

THEOREM V.

If from the three angles of a ſpheric triangle (ABC), *as poles, be deſcribed three arcs of great circles, forming another ſpheric triangle* (EDF); *then will the ſides of the latter, and the oppoſite angles of the former, be the ſupplements of one another: Alſo the angles in the latter, and their oppoſite ſides in the former, are the ſupplements of one another.*



That is, FE and ∠ CAB, FD and ∠ ABC, DE and ∠ ACB, are ſupplements to one another.

Alſo ∠ E and AC, ∠ D and CB, ∠ F and AB, are the ſupplements to one another.

DEM. Now E, the interſections of the arcs about the poles A and C, being 90° diſtant from them, is the pole of the arc AC. (399)

And for the ſame reaſon, D is the pole of CB, and F of AB.

Let the ſides of the triangle ABC be produced to meet the ſides of the triangle DEF, in G and H, I and L, M and N.

Then FI = DL = 90°: Therefore (DL + FI = DL + FL + LI =) DF + LI = 180°.

Therefore DF and LI are ſupplements to one another.

But LI meaſures the angle ABC. (389)

Therefore ∠ ABC and DF are the ſupplements of one another.

And in the ſame manner it may be demonſtrated, that the ∠ BAC and FE, ∠ ACB and DE, are the ſupplements of one another.

Again, ſince BI = AH = 90 degrees. (399)

Therefore (IB + AH = IB + BH + AB =) IH + AB = 180 degrees.

But IH meaſures the angle F. (389)

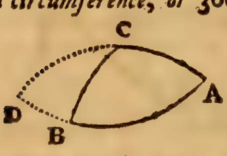
Therefore AB and ∠ F are the ſupplements of one another.

And the ſame may be ſhewn of AC and ∠ E, CB and ∠ D.

476.

THEOREM VI.

The ſum of the three ſides of every ſpheric triangle (ABC) *is leſs than a circumference, or 360 degrees.*



DEM. Continue the ſides AC, AB, till they mee in D.

Then the arcs ACD, ABD, are each 180°. (412

But DC + DB is greater than BC (472

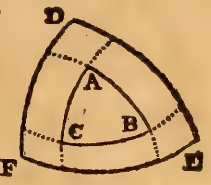
Therefore AC + AB + DC + DB is greater tha AC + AB + BC.

Or the ſemicircles ACD + ABD is greater than AC + AB + BC.

That is, 360° is greater than the three ſides of the triangle ABC.

477. THEOREM VII.

The ſum of the three angles of a ſpheric triangle (ABC) *is greater than two right angles, and leſs than ſix; or will always fall between* 180° *and* 540 *degrees.*



Dem. Since ∠ A and FE, ∠ B and FD, ∠ C and DE, are ſupplements to one another. (475)

Therefore the three angles A, B, C, together with the three ſides FE, FD, DE, make thrice 180°, or 540°.

Now the ſum of the three ſides FE + FD + DE is leſs than twice 180°. (476)

Therefore the ſum of the three angles A+B+C, is greater than 180°.

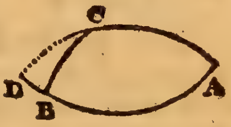
Again, As a ſpheric angle is ever leſs than 180°. (405)

Therefore the ſum of any three ſpheric angles is ever leſs than thrice 180°, or 540 degrees.

478. THEOREM VIII.

If one ſide (AB) *of a ſpheric triangle* (ABC) *be produced, then the outward angle* (CBD) *is either equal to, leſs, or greater than, the inward oppoſite angle* (A) *adjacent to that ſide; according as the ſum of the other two ſides* (CA + CB) *is equal to, greater, or leſs than,* 180 *degrees.*

Dem. Produce AC, AB, to meet in D.



Then ACD = ABD = 180° (412). And ∠ D = ∠ A. (411)

Now if AC + CB is equal to 180°; then CB = CD. And ∠ CBD = (∠ D =) ∠ A. (470)

If AC + CB is greater than 180°; then CB is greater than CD.

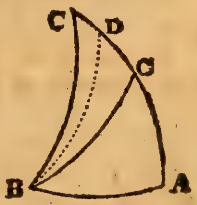
And ∠ CBD is leſs than (∠ D =) ∠ A. (474)

If AC + CB is leſs than 180°; then CB is leſs than CD.

And ∠ CBD is greater than (∠ D =) ∠ A. (474)

479. THEOREM IX.

In right angled ſpheric triangles, the oblique angles and their oppoſite ſides are of the ſame kind: That is, if a leg is leſs or greater than 90°, *its oppoſite angle is alſo leſs or greater than* 90°.



In the right angled ſpheric triangle ABC, right angled at A.

If AC is greater than 90°; then ∠ ABC is greater than 90°.

If AC is leſs than 90°; then ∠ ABC is leſs than 90°.

Dem. Let the leg AC be leſs, AD equal, AC greater, than 90°, and deſcribe the arc DB.

Now D being the pole of AB (417). Therefore ∠ DBA is right.

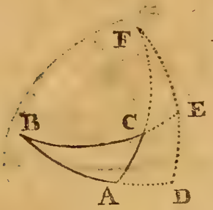
Conſequently if AC is leſs than AD, the ∠ CBA is leſs than ∠ DBA.

But if AC is greater than AD, the ∠ CBA is greater than ∠ DBA.

And the ſame may be proved of the leg AB and its oppoſite angle.

480. THEOREM X.

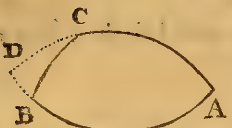
In right angled ſpheric triangles (BAC), *the hypothenuſe* (BC) *is leſs than* 90° *when the legs* (AB, AC) *are of a like kind: But the hypothenuſe is greater than* 90°, *when the legs are of different kinds.*



481. When the legs AB, AC, are both leſs than 90°.
DEM. In BA, AC produced, take BD, AF, equal to quadrants; thro' F and D deſcribe an arc FD meeting BC produced in E.

Now F being the pole of BD (399). Therefore B is the pole of FD.

Conſequently BC is leſs than (BE =) 90°.

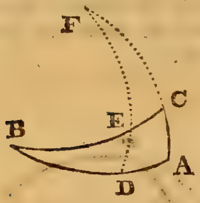


482. When the legs AB, AC, are both greater than 90°.
Produce AC, AB, till they meet in D.

Now the hypothenuſe CB is common to both the right angled triangles BAC and BDC.

And the legs DC, DB, being both leſs than 90°.

Therefore the hypothenuſe BC is leſs than 90°, by art. 481.



483. When the legs AB, AC, are one greater, the other leſs than 90°.

In AB, and AC produced, take BD, AF, each of 90°, and deſcribe the arc FED.
Then B is the pole of FD; ſince F is the pole of BA, and FD is at right angles to BD. Theref. BE = 90°. (417)
Conſequently BC is greater than 90 degrees.

484. COROL. I. The hypothenuſe is leſs or greater than 90°, according as the oblique angles are of a like, or of different kinds.

For if legs are like, or unlike, the angles are like, or unlike. (479)
And if legs are like, or unlike, the hypoth. is acute, or obtuſe. (480)
Therefore if the angles are like, or unlike, the hypothenuſe is acute, or obtuſe.

485. COROL. II. The legs and their adjacent angles are like, or unlike, as the hypothenuſe is leſs or greater than 90 degrees.

For like legs, or like angles, make the hypoth. acute. (481, 482)
And unlike legs, or unlike angles, make the hypoth. obtuſe. (483, 484)

486. COROL. III. A leg and its oppoſite angle are both acute, or both obtuſe, according as the hypothenuſe and other leg are like, or unlike.

This is evident from the three caſes of this Theorem.

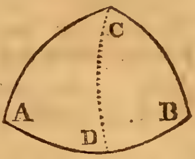
487. COROL. IV. Either angle is acute, or obtuſe, as the hypothenuſe and the other angle are like, or unlike.

This follows from art. 481, 482.

488. THEOREM XI.

In every ſpheric triangle (ABC), *if the angles adjacent to either ſide* (AB) *be alike, then a perpendicular* (CD) *drawn to that ſide from the other angle, will fall within the triangle: But the perpendicular* (CD) *falls without the triangle, when the angles adjacent to the ſide* (AB) *it falls on are unlike.*

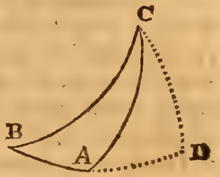
DEMONST. Since in all right angled triangles the perpendicular and its oppoſite angle are of the ſame kind. (479)



Therefore the ∠ CAD and CBD, are each like CD.

Now in Fig. 1. the angles CAD, CBD, or CAB, CBA, are angles adjacent to the baſe AB within the triangle, and are alike.

Therefore the perpendicular falling between A and B, falls within the triangle.



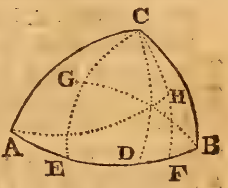
In Fig. 2. the angles CAD and CAB are the ſupplements of each other, and are therefore unlike, as CA falls obliquely on AB.

Therefore ∠ CAB is unlike to ∠ CBA.

Conſequently the perpendicular CD cannot fall beween A and B: Therefore it muſt fall without.

489. THEOREM XII.

If the two leſſer ſides (CA, CB) *of a ſpheric triangle* (ABC) *are of the ſame kind; then an arc* (CD) *drawn from their included angle* (ACB) *perpendicular to the oppoſite ſide* (AB), *will fall within the triangle.*



DEMONST. In AB take AF = AC; draw CF, and AH at right angles to CF.

Then CH = HF (471) are each leſs than 90°. (473)

Alſo take BE = BC; draw CE, and BG at right angles to CE.

Then CG = GE (471) are each leſs than 90°. (473)

Now in the right angled triangles FHA, EGB; if the hypothenuſes AF (= AC), and BE (= BC) are acute, or like FH and EG;

Then the angles AFH and BEG are acute, and like AC and BC; (486)

Therefore the perpendicular CD falls on EF, within the triangle. (488)

Alſo, if the hypothenuſes AF and BE are obtuſe, or unlike to FH and GE;

Then the angles AFH and BEG are obtuſe, and alſo like CA and CB. (486)

Conſequently the perpendicular will fall on EF. (488)

Therefore in either caſe the perpendicular falls within the triangle.

490. THEOREM XIII.

In all right angled ſpheric triangles,

As ſine hypoth. : *Rad* : : *ſine of a leg* : *ſine of its oppoſite angle.*

491. *And ſine a leg* : *Rad* : : *tan. other leg* : *tan. of its oppoſite angle.* Pl. I.

DEMONST. Let EDAFG repreſent the eighth part of a ſphere, where the quadrantal planes EDFG, EDBC, are both perpendicular to the quadrantal plane ADFB; and the quadrantal plane ADGC is perpendicular to the quadrantal plane EDFG; and the ſpheric triangle ABC is right angled at B, where CA is the hypothenuſe, and BA, BC, are the legs.

To the arcs GF, CB, draw the tangents HF, OB, and the ſines GM, CI, on the radii DF, DB; alſo draw BL the ſine of the arc AB, and CK the ſine of AC; then join IK and OL.

Now HF, OB, GM, CI, are all perpendicular to the plane ADFB.

And HD, GK, OL, lie all in the ſame plane ADGC.

Alſo FD, IK, BL, lie all in the ſame plane ADGC.

Therefore the right angled triangles HFD, CIK, OBL, having the equal angles HDF, CKI, OLB, (273) are ſimilar. (250)

Therefore CK : DG :: CI : GM

That is, As ſin. hyp. : Rad :: ſin. of a leg : ſin. opp. angle.

For GM is the ſine of the arc GF, which meaſures the angle CAB. (389)

Alſo, As LB : DF :: BO : FH

That is, As ſin. of a leg : Rad :: tan. of other leg : tan. opp. angle.

492. THEOREM XIV.

In right angled ſpheric triangles (ABC) *if about the oblique angles* (A, C) *as poles, at 90° diſtance, there be deſcribed arcs* (DE, FE) *cutting one another (in* E); *and the ſides* (AB, AC, BC) *of the triangle be produced to cut thoſe arcs (in* D; G, F; H, I), *there will be conſtituted two other triangles* (CGH, HIE), *whoſe parts are either equal to, or are the complements of the parts of the given one.* Pl. I.

DEMONST. Now ſince A is the pole of ED (399). Therefore AD, AG are at right angles to ED; and ſo is ED to AD. (417)

And ſince BI and DE are at right angles to AD, their interſection H is the pole of AD (416). Therefore HB, HD, are quadrants. (415)

Then in the triangle CGH, right angled at G.

CG = complement of AC.

HG = comp. ∠ A; For HG is the comp. of GD, which (389) meaſ. ∠A;

HC the hypoth. is the comp. of CB.

The ∠ HCG = ∠ ACB. (406)

The ∠ CHG = comp. AB; For BD the comp. of AB, meaſures ∠ CHG.

Alſo in the triangle EIH, right angled at I: Becauſe CF, CI are at right angles to EF; and EF, EG being alſo at right angles to AF; therefor E is the pole of AF; (416) conſequently EF and EG are quadrants (415)

Then the hypoth. EH = ∠ A; For GH = comp. of EH and GD; anc GD meaſures the angle A.

HI = CB; For HC = comp. of HI and CB.

EI = comp. ∠ C; For EI = comp. of IF, which meaſures ∠ C.

The ∠ H = comp. AB; For BD, the comp. of AB, meaſures ∠ H.

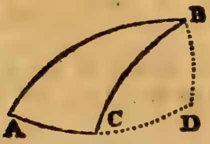
The ∠ E = AC; For GF, the meaſure of ∠ E, is equal to AC.

493. THEOREM XV.

In every ſpheric triangle, it will be.

As the ſine of either angle, is to the ſine of its oppoſite ſide;

So is the ſine of another angle, to the ſine of its oppoſite ſide.



Let ABC be a ſpheric triangle, wherein BD is perpendicular to AC produced; forming the two righ angled triangles ADB, CDB.

DEM. Now ſin. AB : rad :: ſin. BD : ſin.∠A. (490

And ſin. BC : rad :: ſin. BD : ſin.∠C.

Therefore ſin. AB × ſin. ∠A = rad × ſin. BD. (245

And ſin. BC × ſin. ∠C = rad × ſin. BD. (245

Therefore ſin. AB × ſin. ∠A = ſin. BC × ſin. ∠C. (137

Therefore ſin. ∠A : ſin. BC :: ſin. ∠C : ſin. AB. (246

SECTIO

SECTION VI.

Of the ſolution of right angled ſpheric triangles.

In every caſe of right angled ſpheric triangles, three things beſide the radius enter the proportion, whereof two are given, and the third is ſought.

Now the ſolution of every caſe will be obtained by the application of the two following rules to Theorem XIII and XIV. (490, 491, 492)

494. Rule I. If of the three things concerned, or their complements, two are oppoſite to one another, and the third is oppoſite to the right angle, in one of the triangles marked 1, 2, 3, in the fig. to Theo. XIV. Pl. I. Then the thing ſought will be found by the firſt proportion (490) either directly, or by inverſion.

495. Rule II. If of the three things concerned, or their complements, two are legs, and the third is an oblique angle, in either of the hree triangles marked 1, 2, 3, in fig. to Theo. XIV. Pl. I. Then the hing ſought will be found by the ſecond proportion (491), either directly, or by inverſion.

496. PROBLEM I.

In the right angled ſpheric triangle ABC, Plate I. Theorem XIV.

Given the hypothenuſe AC and one of the legs AB } Required the reſt.

1ſt. *To find the angle* ACB *oppoſite the given leg* AB.

Here the things concerned are AC, ∠ B, AB, ∠ C; which are found in he triangle N° 1, to be oppoſite; and ſo fall under Rule I. (494)

Then ſin. AC : rad : : ſin. AB : ſin. ∠ ACB. (490)

Or ſin. hyp. : rad : : ſin. g. leg. : ſin. op. ∠. Like the g. leg. (479)

2d. *To find the angle* CAB *adjacent to the given leg* AB.

Here the things concerned are AC, ∠ B, AB, ∠ A.

Now trying in the triangle N° 1, I find the things concerned will all under neither of the Rules.

But trying in the triangle N° 2, the things concerned, or their complements, fall under Rule II. (495)

Then ſin. HG : rad : : tan. GC : tan. ∠ CHG. (491)

Or coſ. ∠ CAB : rad : : cot. AC : cot. AB.

Or coſ. ∠ CAB : cot. AC : : (rad : cot. AB) : : tan. AB : rad. (331)

Therefore rad : cot. hyp. : : tan. g. leg : coſ. adj. angle (228)

Like, or unlike the giv. leg; as the hyp. is acute, or obtuſe. (485)

3d. *To find the other leg* BC.

Here the things concerned are AC, ∠ B, AB, BC; which in the triangle, N° 1, do not fall under either Rule: But in N° 2 they will be ound to fall under the firſt Rule. (494)

Then ſin. HC : rad : : ſin. CG : ſin. ∠ CHG. (490)

Or coſ. CB : rad : : coſ. AC : coſ. AB.

Therefore coſ. g. leg (AB) : rad : : coſ. hyp. (AC) : coſ. req. leg. (CB)

And is acute, if hyp. and giv. leg are like: But obtuſe if unlike. (486)

497. PROBLEM II.

In the right angled ſpheric triangle ABC. Pl. I. Theo. XIV.
Given the hypothenuſe AC } Required the reſt.
And one of the oblique angles A }

1ſt. *To find the leg* CB *oppoſite the given angle* A.

In the triangle, N° 1, the things concerned fall under Rule I. (494)
Then rad : ſin. AC : : ſin. ∠CAB : ſin. CB. (490)
Or rad : ſin. hyp. : : ſin. giv. angle : ſin. opp. ſide.
And is like the given angle. (479)

2d. *To find the leg* AB *adjacent to the given angle* A.

In the triangles, N° 2 or 3, the things concerned fall under Rule II. (495)
Then ſin. HG : rad : : tan. CG : tan. ∠CHG. (491)
Or coſ. ∠BAC : rad : : (cot. AC : cot. AB : :) tan. AB : tan. AC. (332)
Therefore rad : tan. AC : : coſ. ∠ BAC : tan. AB. (228)
Or rad : tan. hyp. : : coſ. giv. angle : tan. adjacent leg.
And is acute, if hyp. and giv. angl. are alike ; but obtuſe if unlike. (487)

3d. *To find the other angle* ACB.

In the triangle, N° 2, the things concerned fall under Rule II. (495)
Then ſin. CG : rad : : tan. GH : tan. ∠ HCG. (491)
Or coſ. AC : rad : : (cot. ∠BAC : tan. ∠BCA : :) cot. ∠BCA : tan. ∠BAC. (332)
Therefore rad : tan. ∠ BAC : : coſ. AC : cot. ∠ BCA. (228)
Or rad : coſ. hypoth. : : tan. giv. ang. : cot. req. angle.
And is acute, if hyp. and giv. ang. are alike ; but obtuſe if unlike. (487)

498. PROBLEM III.

In the right angled ſpheric triangle ABC. Pl. I. Theo. XIV.
Given one of the legs AB } Required the reſt.
And is oppoſite angle ACB }

1ſt. *To find the hypothenuſe* AC.

In the triangle, N° 1, the things concerned fall under Rule I. (494)
Then ſin. ∠ ACB : ſin. AB : : rad : ſin. AC. (490)
Or ſin. giv. ang. : ſin. giv. leg : : rad : ſin. hyp.
And is either acute or obtuſe.

2d. *To find the other leg* CB.

In the triangle, N° 1, the things concerned fall under Rule II. (495)
Then ſin. CB : (rad : :) tan. AB (: tan. ∠ACB) : : cot. ∠ACB : rad. (331)
Or rad : cot. giv. ang. : : tan. giv. leg : ſin. req. leg.
And is either acute or obtuſe.

3d. *To find the other angle* CAB.

In the triangle, N° 3, the things concerned fall under Rule I. (494)
Then ſin. EH : rad : : ſin. EI : ſin. ∠ IHE. (490)
Or ſin. ∠BAC : rad : : coſ. ∠ACB : coſ. AB.
Or coſ. giv. leg : coſ. giv. ang. : : rad : ſin. required angle.
And is either acute or obtuſe.

499.

499. PROBLEM IV.

In the right angled ſpheric triangle ABC. Plate I. Theorem XIV.
Given one of the legs AB }
And its adjacent angle BAC } Required the reſt.

1ſt. *To find the other angle* BCA.

In the triangle, N° 3, the things concerned fall under Rule I. (494)
Then rad : ſin. EH : : ſin. ∠EHI : ſin. EI. (490)
Or rad : ſin. ∠BAC : : coſ. AB : coſ. ∠ACB.
Therefore rad : coſ. giv. leg : : ſin. giv. ang. : coſ. req. angle.
And is like the given leg. (479)

2d. *To find the other leg* BC.

In the triangle, N° 1, the things concerned fall under Rule II. (495)
Then ſin. AB : rad : : tan. BC : tan. ∠CAB. (491)
Or rad : ſin. AB : : tan. ∠CAB : tan. BC.
Therefore rad : ſin. giv. leg : : tan. giv. ang. : tan. req. leg.
And is like the given angle. (479)

3d. *To find the hypothenuſe* AC.

In the triangle, N° 2, the things concerned fall under Rule II. (495)
Then ſin. GH : rad : : tan. CG : tan. ∠CHG. (491)
Or coſ. ∠CAB : rad : : cot. AC : cot. AB.
Therefore rad : coſ. giv. ang. : : cot. giv. leg : cot. hypothenuſe.
And is acute, if the giv. leg and angle are alike; but obtuſe if unlike. (485)

00. PROBLEM V.

In the right angled ſpheric triangle ABC. Plate I. Theorem XIV.
Given both the legs AB, BC.
Required the reſt.

1ſt. *To find either of the oblique angles, as* BAC.

In the triangle, N° 1, the things concerned fall under Rule II. (495)
Then, As ſin. AB : rad : : tan. BC : tan. ∠BAC. (491)
Or rad : ſin. AB : : (tan. ∠BAC : tan. BC : :) cot. BC : cot. ∠BAC. (332)
Therefore rad : ſin. one leg : : cot. oth. leg. : cot. opp. angle.
And is like its oppoſite leg. (479)

2d. *To find the hypothenuſe* AC.

In the triangle, N° 2, the things concerned fall under Rule I. (494)
Then, As rad : ſin. HC : : ſin. ∠CHG : ſin. CG. (490)
Or rad : coſ. BC : : coſ. AB : coſ. AC.
Therefore rad : coſ. one leg : : coſ. oth. leg : coſ. hypothenuſe.
And is acute, if the legs are alike; but obtuſe if unlike. (480)

501. PROBLEM VI.

In the right angled ſpheric triangle ABC. Plate I. Theorem XIV.
Given both the angles BAC, BCA.
Required the reſt.

1ſt. *To find either of the legs, as* BC.

In the triangle, N° 2 or 3, the things concerned fall under Rule I. (494)
Then rad : ſin. HC : : ſin. ∠ HCG : ſin. HG. (490)
Or rad : coſ. BC : : ſin. ∠ ACB : coſ. ∠BAC.
Therefore ſine of one angle : rad : : coſ. oth. ang. : coſ. opp. ſide.
And is like its oppoſite angle. (479)

2d. *To find the hypothenuſe* AC.

In the triangle, N° 2, the things concerned fall under Rule II. (495)
Then, As ſin. CG : rad : : tan. GH : tan. ∠ HCG. (491)
Or coſ. AC : (rad : :) cot.∠BAC (: tan.∠BCA) : : cot.∠BCA : rad. (331)
Therefore rad : cot. one angle : : cot. oth. ang. : coſ. hypothenuſe.
And is acute, if the angles are like. (484)
But obtuſe if unlike.

In theſe ſix Problems are contained ſixteen proportions, which are applicable to the like number of caſes uſually given to right angled ſpheric triangles; and theſe proportions being collected and diſpoſed in a Table, will readily ſhew, by inſpection, how any of the caſes are to be ſolved.

The celebrated Lord NAPIER, the inventor of logarithms, contrived a general rule, eaſy to be remember'd, whereby the ſolution of every caſe in right angled ſpheric triangles is readily obtained, where the tabl of proportions is wanting; which rule is as follows.

GENERAL RULE.

502. *Radius multiplied by the ſine of the middle part, is either equal to the product of the tangents of extreams conjunct.*
Or to the product of the coſines of extremes disjunct.
Obſerving ever to uſe the complements of the hypoth. and angles.

Lord *Napier* called the five parts of every right angled ſpheric triangle, omitting the right angle, circular parts; which he thus diſtinguiſhed; the *two legs*, the *complements of the two angles*, and the *complement of the hypothenuſe*; and any two of theſe circular parts being given, the others are to be found by this rule, as is ſhewn in what follows.

Now, In all the proportions about right angled ſpheric triangles, there are, beſides the radius, three things concerned; one whereof may be called the middle term in reſpect of the other two; and theſe two, in reſpect to the middle term, may be called extreams.

When the two extreams are joined to the middle, they are called extreams conjunct: But when each of them are disjoined from the middle by an intermediate term (not concerned), they are then called extreams disjunct; taking notice that the right angle does not disjoin the legs.

Theſ

Theſe things duly obſerved, the practice of the Rule will appear in the following examples.

Example I. *When the hypothenuſe and the angles are concerned.*

The hypoth. is the middle term, and the two angles are extreams conjunct; then by the rule.

Rad × ſin. hyp. = tan. one ang. × tan. other angle.

But the compl. of the hypoth. and angles are always to be uſed.

Therefore rad × coſ. hyp. = cot. one ang. × cot. oth. angle.

Hence rad : cot. one ang. : : cot. oth. angle : coſ. hypoth. (246)

From whence are deduced the 6th and 15th caſes.

Exam. II. *When the hypoth. and legs are under conſideration.*

The hypoth. is the middle term, and the two legs are extreams diſjunct, having the angles between them and the hypoth.

Then by the rule. Rad × ſin. hyp. = coſ. one leg × coſ. oth. leg.

But the complement of the hypoth. is to be uſed.

Therefore rad × coſ. hy. = coſ. one leg × coſ. oth. leg.

Hence rad : coſ. one leg : : coſ. oth. leg. : coſ. hypoth. (246)

From whence are deduced the 3d and 13th caſes.

Exam. III. *The legs and an angle under conſideration.*

Here one leg is the middle, and the angle and other leg are extreams onjunct;

And theſe being reſolved into a proportion by the rule, will produce he 8th, 11th, and 14th caſes.

Exam. IV. *The angles and a leg under conſideration.*

Here one angle is the middle, and the other angle and leg are extreams diſjunct, the hypothenuſe and other leg intervening.

Now theſe being reſolved into a proportion, gives the 9th, 12th, and 16th caſes.

Exam. V. *The hypoth. a leg, and the angle between them being under onſideration.*

Here the angle is the middle term, and the hypoth. and leg are extreams conjunct.

And theſe being reſolved into a proportion, will give the 2d, 4th, and 10th caſes.

Exam. VI. *The hypothenuſe, a leg and its oppoſite angle being under onſideration.*

Here the leg is the middle term, and the hypothenuſe and angle are xtreams diſjunct, the other leg and other angle falling between them nd the middle.

And theſe being converted into a proportion, from thence the 1ſt, 5th, nd 7th caſes are deduced.

SECTION VII.

Of the ſolution of oblique angled ſpheric triangles.

503. All the caſes in oblique angled ſpheric triangles, except where the three ſides, or the three angles are given, are moſt conveniently reſolved by drawing a perpendicular from one of the angles to its oppoſite ſide, continued if neceſſary; which perpendicular will either divide the given triangle into two right angled triangles, or make two that are right angled, by joining a right angled one to the given triangle.

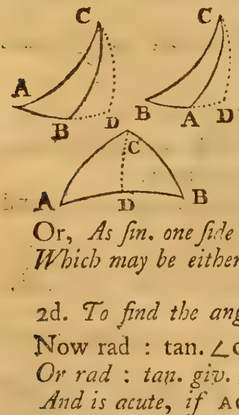
In drawing of this perpendicular obſerve:

1ſt. It muſt be drawn from the end of a given ſide, and oppoſite to a given angle.

2d. It muſt be ſo drawn, that two of the given things in the oblique triangle may remain known in one of the right angled triangles.

3d. This perpendicular is to be uſed as a known quantity; and being drawn as here directed, will either fall within or without the triangle, as the angles, next the ſide on which it falls, are of the ſame or of different kinds. (488)

504. PROBLEM I.



In the oblique angled ſpheric triangle ABC.
Given two ſides . . . CA, CB } Requir. the reſt.
And the angle opp. to one, ∠CAB }

1ſt. *To find the angle oppoſite to the other given ſide* (∠CBA).

As ſin. BC : ſin.∠CAB : : ſin. AC : ſin.∠CBA. (493)
Or, *As ſin. one ſide : ſin. opp. ang. : : ſin. oth. ſide : ſin. opp. angle.*
Which may be either acute or obtuſe.

2d. *To find the angle between the given ſides* (∠ACB).

Now rad : tan.∠CAB : : coſ. AC : cot. (ACD, call it) m. (3d. 497)
Or rad : tan. giv. ∠ : : *coſ. adj. ſide : cot. (of a fourth =) m.*
And is acute, if AC *and* ∠CAB *are like: But obtuſe if unlike.*
But rad : tan. CD : : cot. AC : coſ. (ACD =) m. (2d. 496)
rad : tan. CD : : cot. CB : coſ. (BCD, call it) n.
Therefore cot. AC : cot. CB : : coſ. m. : coſ. n. (238)
Or cot. ſide adj. giv. ∠ : *cot. oth. ſide : : coſ. m : coſ. n.*
And is like the ſide oppoſite the given angle, if that angle is acute;
But unlike that ſide, if the given angle is obtuſe.

Then the angle ſought, viz. ∠ACB = { *ſum of m and n, if* ⊥* *falls within.*
{ *diff. of m and n, if* ⊥ *falls without.*

---

* The mark ⊥ ſignifies the perpendicular.

3d. *To find the other ſide* AB.

Now Rad : coſ. ∠CAB : : tan. AC : tan. (AD, call it) M. (2d. 497)

Or Rad : coſ. giv. ang. : : tan. adj. ſide : tan. (of a fourth =) M.

Acute, if the ang. and its adj. ſide are alike; but obtuſe if unlike.

But coſ. CD : Rad : : coſ. AC : coſ. (AD =) M.

coſ. CD : Rad : : coſ. CB : coſ. (DB, call it) N. (3d. 496)

Therefore coſ. AC : coſ. CB : : coſ. M : coſ. N. (238)

Or coſ. ſide adj. giv. ang. : coſ. oth. ſide : : coſ. M *: coſ.* N.

Like the ſide oppoſite the given angle, if that angle be acute.

But unlike that ſide, if the angle be obtuſe.

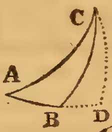
$$\textit{Then the ſide ſought } AB = \begin{cases} \textit{ſum of } M \textit{ and } N\textit{, if the } \perp \textit{ falls within.} \\ \textit{diff. of } M \textit{ and } N\textit{, if the } \perp \textit{ falls without.} \end{cases}$$

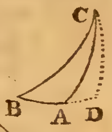
But if CA = CB, or if CA = 180° − CB, or if CA is between BC and 180° — BC;

Then ∠B is like BC only.

$$\text{And if BC is} \begin{cases} \text{like } \angle A \\ \text{unlike } \angle A \end{cases} ; \begin{cases} \text{Then } \angle ACB = m \pm n \text{ only; and AB} \\ = M \pm N \text{ only.} \end{cases}$$

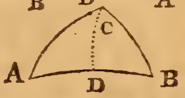
505. PROBLEM II.





In the oblique angled ſpheric triangle ABC.

Given two angles ∠CAB, ∠CBA } Required
And a ſide oppoſite one of them AC } the reſt.



1ſt. *To find the ſide oppoſite the other given angle, viz.* CB.

Then, As ſin. ∠CBA : ſin. AC : : ſin. ∠CAB : CB. (493)

Or ſin. one ang. : ſin. opp. ſide : : ſin. oth. ang. : ſin. opp. ſide.

Which may be either acute or obtuſe.

2. *To find the ſide included by the given angles, viz.* AB.

Now Rad : coſ. ∠CAB : : tan. AC : tan. (AD, call it) M. (2d. 497)

Or Rad : coſ. ∠ adj. giv. ſide : : tan. the giv. ſide : tan. (of a fourth =) M.

Like the ang. adj. the ſide given, if that ſide is acute; but unlike if obtuſe.

But Rad : tan. CD : : cot. ∠CAB : ſin. (AD =) M.

Rad : tan. CD : : cot. ∠CBD : ſin. (DB, call it) N. (2d. 498)

Therefore cot. ∠CAB : cot. ∠CBD : : ſin. M : ſin. N. (238)

Or cot. ∠ adj. giv. ſide : cot. oth. ang. : : ſin. M *: ſin.* N.

Which may be either acute or obtuſe.

$$\textit{Then ſide ſought } AB = \begin{cases} \textit{ſum of } M \textit{ and } N\textit{, if the given angles are alike.} \\ \textit{diff. of } M \textit{ and } N\textit{, if the given angles are unlike.} \end{cases}$$

3d. *To find the other angle, viz.* ∠ACB.

Now Rad : tan. ∠CAD : : coſ. AC : cot. (∠ACD, call it) m. (3d. 497)

Or Rad : tan. ∠ adj. ſide giv. : : coſ. of giv. ſide : cot. (of a fourth =) M.

Like ∠ adj. ſide given, if that ſide is acute; but unlike if obtuſe.

But coſ. CD : Rad : : coſ. ∠CAB : ſin. (∠ACD =) m.

coſ. CD : Rad : : coſ. ∠ABC : ſin. (∠BCD, call it) n. (3d. 498)

Therefore coſ. ∠CAB : coſ. ∠ABC : : ſin. m : ſin. n. (238)

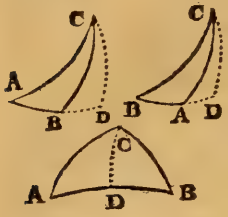
Or coſ. ∠ adj. ſide giv. : coſ. other angle : : ſin. m : ſin. n.

Which may be either acute or obtuſe.

The

$$\textit{Then } \angle \textit{ ſought, } \mathrm{ABC} = \begin{cases} \textit{ſum of m and n, if the given angles are alike.} \\ \textit{diff. of m and n, if the given angles are unlike.} \end{cases}$$

But if AC = BC, or to 180° — BC, or is between BC and 180° — BC.
Then BC cannot be unlike its oppoſite angle.
Neither can DB, or the ∠BCD, be obtuſe.



506. PROBLEM III.

In the oblique angled ſpheric triangles ABC.
Given two ſides AC, AB }
And their contained angle BAC } Required the reſt.

1ſt. *To find either of the other angles,* as ∠ABC.
As Rad : coſ. ∠CAB : : tan. AC : tan. (AD, call it) M. (2d. 297)
Or Rad : coſ. giv. ∠ : : tan. ſide opp. ∠ ſought : tan. (of a fourth =) M.
Like the ſide opp. ∠ ſought, if the given ∠ is acute.
But unlike that ſide, if the given ∠ is obtuſe.
*Take the diff. between (*AB*) ſide adj. ∠ ſought, and (*AD =*)* M ; *call it* N.
Now Rad : cot. CD : : ſin. (AD =) M : cot. ∠ CAB. (1ſt. 500)
Rad : cot. CD : : ſin. (DB =) N : cot. ∠ ABC.
Therefore ſin. N : ſin. M : : cot. ∠ ABC : cot. ∠CAB. (238)
: : tan. ∠CAB : tan. ∠CBA. (332)
Or ſin. N *: ſin.* M *: : tan. giv. ∠ : tan. ∠ ſought.*
*Like the given angle (*BAC*) if* M *is leſs than (*AB*) the ſide adjacent the angle ſought : But unlike if* M *is greater.*

2d. *To find the other ſide* CB.
As Rad : coſ. ∠CAB : : tan. AC : tan. (AD, call it) M. (2d. 297)
Or Rad : coſ. giv. ∠ : : tan. of either giv. ſide : tan. (of a fourth =) M.
Like the ſide uſed in this proportion if the given angle is acute.
But unlike that ſide, if the angle is obtuſe.
*Take the diff. between the other ſide (*AB*) and (*AD =*)* M ; *call it* N.
Now Rad : coſ. CD : : coſ. (AD =) M : coſ. AC. (2d. 500)
Rad : coſ. CD : : coſ. (DB =) N : coſ. CB.
Therefore coſ. M : coſ. N : : coſ. AC : coſ. CB. (238)
Or coſ. M *: coſ.* N *: : coſ. ſide uſed in 1ſt proportion : coſ. ſide required.*
Like N, *if the giv. ∠ is acute : But unlike* N *if that ∠ is obtuſe.*

507. PROBLEM IV.

In the oblique angled ſpheric triangle ABC.
Given two angles ∠CAB, ∠ACB }
And their included ſide AC } Required the reſt.

1ſt. *To find either of the other ſides, as* CB.
As Rad : coſ. AC : : tan. ∠ CAB : cot. (∠ACD, call it) m. (3d. 497)
Or Rad : coſ. giv. ſide : : tan. ∠ opp. ſide ſought : cot. (of a fourth =) m.
Like the angle opp. ſide ſought, if the given ſide is acute.
But unlike that angle, if the given ſide be obtuſe.
*Take the diff. between ∠ (*ACB*) adj. ſide ſought, and (∠*ACD =*) m, call it n*
Then Rad : cot. CD : : coſ. (∠ACD =) m : cot. AC. (3d. 499.
Rad : cot. CD : : coſ. (∠ BCD =) n : cot. CB.

Therefore coſ. n : coſ. m : : cot. CB : cot. AC. (238)
: : tan. AC : tan. CB. (332)

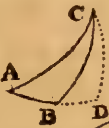
Or coſ. n : coſ. m : : tan. given ſide : tan. ſide required.
Like n, if the angle oppoſite the ſide ſought be acute.
But unlike n if the angle is obtuſe.

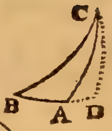
2d. *To find the other angle* ABC.

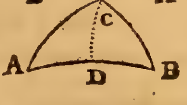
As Rad : coſ. AC : : tan. ∠CAB : cot. (∠ACD, call it) *m*. (3d. 497)

Or Rad : coſ. giv. ſide : : tan. either giv. ∠ *: cot. (of a fourth =) m.*
Like ∠ *uſed in this proportion, if the giv. ſide* (AC) *is acute.*
But unlike that ∠, *if the given ſide is obtuſe.*

Take the diff. between the other ∠ (ACB) *and* ∠ (ACD =) *m, call it n.*







Now Rad : coſ. CD : : ſin. (∠ ACD =) *m* : coſ. ∠CAB. (1ſt. 499)
Rad : coſ. CD : : ſin. (∠ BCD =) *n* : coſ. ∠ABC.

Therefore ſin. m. : ſin. n : : coſ. ∠CAB : coſ. ∠ABC. (238)

Or ſin. m *: ſin.* n *: : coſ.* ∠ *uſed in 1ſt prop. : coſ.* ∠ *ſought.*
Like the ∠ *uſed in both proportions, if* m *is leſs than the other* ∠.
But unlike, if m *is greater than the other angle.*

508. PROBLEM V.

In the oblique angled ſpheric triangle ABC. Plate I. Problem V.
Given the three ſides AB, BC, AC; Required the angles.

To find the angle ABC.

Let HBKLM repreſent the quarter of a ſphere, whoſe centre is O. Where the ſemicircular ſections HBK, HLK, are at right angles to one nother; and OB is perpendicular to HK.

Then, continuing the ſide BC to L, the arc HML meaſures ∠ABC. (389)
And HQ = $\frac{1}{2}$ chord HL, will be the ſine of $\frac{1}{2}$ (arc HML = $\frac{1}{2}$) ∠ABC.

Draw the radius OQM; and draw LP, QN at right angles to HK.
Then LP = ſine, HP = verſed ſine, of ∠ABC : And HN = NP. (248)
But as HQO is a right angled triangle; OQ being perp. to HL. (208)
Therefore OH : HQ : : HQ : HN. (253)
And OH × HN = $\overline{HQ}^2$ (245) = ſquare of the ſine of $\frac{1}{2}$ ∠ABC.
Make BD = BE = BC; and AF = AG = AC.

Then the ſemicircular plane DCE, which is parallel to HLK (403), will e cut by the ſemicircular plane FCG, drawn at right angles to the plane BK, in the line CI (283) at right angles to DE. (284)

And the arc DC and its verſed ſine DI, are ſimilar to the arc HL and ts verſed ſine HP. (409, 310)

Then Rad OH : Rad DS : : PH : ID = $\left(\frac{PH}{OH} \times DS = \right) \frac{2HN}{OH} \times DS$.

Draw OR parallel to FG; then arc AR = (90° =) arc BK, and RK = AB.
Therefore ∠ DIF = (∠KOR = arc RK =) arc AB.
Now DS = (SE = ſine arc BE =) ſine arc BC.
And AD = (BD — BA = BC — BA =) diff. ſides about ∠ ſought.
Alſo ∠DFI = $\frac{1}{2}$ arc (DG = AG + AD =) $\overline{AC + AD}$, whoſe ſine is $\frac{1}{2}$ ID. chol. to art. 340.
And arc FD = (AF — AD =) AC — AD, whoſe ſine is $\frac{1}{2}$ DF.

Now ſin. $\angle DIF :$ ſin. $\angle DFI :: (FD : ID ::) \frac{1}{2}FD : \frac{1}{2}ID$. (Schol. 340)

Or ſin. $\angle DIF :$ ſin. $\angle DFI :: \frac{1}{2} FD : \frac{HN}{OH} \times DS$.

Therefore ſin. $\angle DIF \times DS \times \frac{HN}{OH} =$ ſin. $\angle DFI \times \frac{1}{2} FD$. (245)

Therefore ſin. $\angle DIF \times DS \times \frac{HN}{OH} \times OH =$ ſin. $\angle DFI \times \frac{1}{2} FD \times OH$. (239)

Or ſin. $\angle DIF \times DS \times HN =$ ſin. $\angle DFI \times \frac{1}{2} FD \times OH$. (232)

Theref. ſin. $\angle DIF \times DS :$ ſin. $\angle DFI \times \frac{1}{2} FD :: OH : HN$. (246)

$:: OH \times OH : (HN \times OH =) \overline{HQ}^2$. (234)

Therefore ſin. $\angle DIF \times DS :$ ſin. $\angle DFI \times \frac{1}{2} FD :: \overline{OH}^2 : \overline{HQ}^2$.

Or ſin. $AB \times$ ſin. $BC :$ ſin. $\frac{1}{2} \overline{AC + AD} \times$ ſin. $\frac{1}{2} \overline{AC - AD} :: \overline{Rad}^2 : \overline{\text{ſin.} \frac{1}{2} \angle ABC}^2$.

$$\text{Theref. ſquare ſin. } \tfrac{1}{2} \angle ABC = \frac{\text{ſin.} \frac{1}{2} \overline{AC + AD} \times \text{ſin.} \frac{1}{2} \overline{AC - AD}}{\text{ſin. } AB \times \text{ſin. } BC} \times \text{ſqu. Rad.} \quad (247)$$

Now ſuppoſing Rad $= 1$. and L, to ſtand for logarithm.

Then 2 L, ſin. $\frac{1}{2} \angle ABC =$ L, ſin. $\frac{1}{2} \overline{AC + AD} +$ L, ſin. $\frac{1}{2} \overline{AC - AD} -$ L. ſin. AB $-$ L. ſin. BC. (90. 85. 86).

And putting *l* for the arith. comp. of a logarithm.

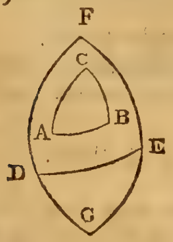
$$\text{Then L, ſin.} \tfrac{1}{2} \angle ABC = \frac{l, \text{ſin.} AB + l. \text{ſin.} BC + \text{L.ſin.} \frac{1}{2} \overline{AC + AD} + \text{L.ſin.} \frac{1}{2} \overline{AC - AD}}{2}.$$

That is, having determined which angle to find.

To the arith. comp. of log. ſin. of one containing ſide,
Add the arith. comp. of log. ſin. of the other containing ſide,
And the log. ſin. of the ½ ſum of 3d ſide and diff. of the containing ſides,
Alſo the log. ſin. of the ½ diff. of 3d ſide and diff. of the containing ſides.
Then the degrees anſwering to half the ſum of theſe four logs, found among the ſines, being doubled, will give the angle ſought.

509.

PROBLEM VI.



In the oblique angled ſpheric triangle ABC.

Given the three angles A, B, C; Requ. the ſides.

To find the ſide AB.

About the given angles as poles, deſcribe arcs o great circles meeting one another, and forming the triangle FDE.

Then are the ſides of FDE, the ſupplements of the angles A, B, C. (475)

Continue FD, FE, the ſupplements of the angles B, A, adjacent to the ſide AB required, till they meet in G.

Then in the triangle DGE, the ſides GD, GE, are the meaſures o the angles B and A, adjacent to the ſide ſought.

The ſide DE is the ſupplement of ∠C opp. the ſide AB.

Now ∠G (= ∠F, by 411) is the ſupplement of AB.

Therefore the ∠G being found in the triangle DGE by PROB. V, (508) will give the ſupplement of the ſide AB required.

That is, Let the given angles be taken as the ſides of another triangle. obſerving to uſe the ſupplement of that angle opp. to the ſide required.

In this new triangle find (by PROB. V*), the angle oppoſite to that ſid where the ſupplement is uſed.*

Then will the ſupplement of the angle thus found be the ſide required.

A TA

ABLE *containing all the caſes of Right angled, or Quadrantal, ſpheric triangles, with the Solutions, and Determinations.*

Given.	*Required.*	SOLUTION.	*Determination.*
Hyp. and a leg	∠ op. gn. leg	ſin Hyp. : Rad :: ſin gn. leg : ſin. op. ∠	Like given leg.
	∠ ad. gn. leg	Rad : cot. Hyp. :: tan. gn leg : coſ. adj. leg	ac. or ob. as hyp. lik. or unl. gn. leg.
	oth. leg.	coſ. gn leg : Rad :: coſ. Hyp. : coſ. req. leg	ac. or ob. as hyp. lik. or unl. gn. leg.
Hyp. and an angle.	leg op. gn. ∠	Rad : ſin. Hyp. :: ſin. gn. ∠ : ſin. op. leg	Like given angle.
	leg ad. gn. ∠	Rad : tan. Hyp. :: coſ. gn. ∠ : tan. adj. leg	ac. or ob. as hyp. lik. or unl. gn ∠
	oth. angle	Rad : coſ. Hyp. :: tan. gn. ∠ : cot req. ∠	ac. or ob. as hyp. lik. or unl. gn. ∠.
A leg and its op. ∠	Hypoth.	ſin. gn. ∠ : ſin. gn. leg. :: Rad : ſin. Hyp.	either ac. or ob.
	oth. leg	Rad : cot. gn. ∠ :: tan. gn. leg. : ſin. req. leg	either ac. or ob.
	oth. angle	coſ. g. leg : coſ. gn. ∠ :: Rad : ſin. req. ∠	either ac. or ob.
A leg and its adj. ∠	oth. ang.	Rad : coſ. gn. leg :: ſin. gn. ∠ : coſ. req. ∠	Like given angle.
	oth. leg.	Rad : ſin. gn. leg :: tan. gn. ∠ : tan. req. leg	Like given leg.
	Hypoth.	Rad : coſ. gn. ∠ :: cot. gn. leg : cot. Hyp.	ac. or ob. as gn. leg. lik. or unl. gn. ∠.
Both legs.	either ang.	Rad : ſin. eith. leg :: cot. oth. leg : cot. op. ∠	Like opp. leg.
	Hypoth.	Rad : coſ. eith. leg :: coſ. oth. leg : coſ. Hyp.	ac. or ob. as legs like or unlike.
Both angles	eith. leg.	ſin. eith. ∠ : Rad :: coſ. oth. ∠ : coſ. op. leg	Like opp. angle.
	Hypoth.	Rad : cot. eith. ∠ :: cot. oth. ∠ : coſ. Hyp.	ac. or ob. as ∠s lik. or unl.

n a quadrantal triangle, if the quadrantal ſide be called radius; the ſupplement of oppoſite to that ſide be called hyp.; the other ſides be called angles, and their ngles be called legs: Then the ſolution of all the caſes will be as in this table; r, that where the kind of a ſide or angle is determined by the hyp.; or the hyp. is to ined, to uſe unlike inſtead of like, and like inſtead of unlike.

table, beſide the contractions for ſine, tang. coſine, cotang, *op.* ſtands for oppo- for adjacent; *oth.* for other; *eith.* for either; *ac.* for acute; *ob.* for obtuſe; *gn.* for k, *unl.* for like, unlike; *req.* for required; *ang.* or ∠, for angle.

A TABLE containing all the caſes of Oblique angled ſpheric triangles, with the Solutions and Determinations.

	PROB.	Given	Required	SOLUTION.	Determination.
527.			∠op. oth. ſid.	ſin. one ſide : ſin. op. ∠ :: ſin. oth. ſide : ſin. op. ∠	either ac. or ob.
528.	I.	Two ſides and an ang. op. to one	∠bet. gn. ſid.	Rad : tan. gn. ∠ :: coſ. adj. ſid. : cot. cot.ſid.adj.gn.∠ : cot. oth. ſid. :: coſ. *m* : coſ. n Then req. angle is either equal to ſum, or diff. of m and n.	ac. or ob. as gn. angle and it adj. ſide are like or unlike. like or unlike ſid. op. gn. angl. as that angl. is ac. or ob. as gn. ſides are like or unlike.
529.			other ſide	Rad : coſ. gn. ∠ :: tan. adj. ſid. : tan. M coſ. S. adj. gn.∠ : coſ. oth. S. :: coſ. M : coſ. N Then required ſide = ſum or diff. of M and N,	ac. or ob. as given angl. and its adj. ſide are like or unlike. like or unlike ſide op. gn. angl. as that angl. is ac. or ob. as the given ſides are lik. or unl.
530.			S. op. oth.∠	ſin. one angle : ſin. op. S. :: ſin. oth. angle : ſin. op. S.	either ac. or ob.
531.	II.	Two angles and a ſide op. to one	S. bet. gn. ∠s	Rad : coſ.∠adj.gn.S. :: tan. gn. S. : tan. M cot.∠ adj. gn. S. : cot. oth. ang. :: ſin. M : ſin. N Then required ſide = ſum or diff. of M and N,	lik. or unl. angl. adj. gn. ſide, as that ſide is ac. or ob. either ac. or ob. as the given angles are like or unlike.
532.			other angle	Rad : tan.∠adj.gn.S. :: coſ. gn. ſid. : cot. m coſ.∠ adj. gn. S. : coſ. oth. ang. :: ſine m : ſine n Then required angle = ſum or diff. of m and n,	lik. or unl. angl. adj. gn. ſide, as that ſide is ac. or ob. either ac. or ob. as the given angles are like or unlike.
			either of	Rad : coſ. gn. ang. :: tan.S.op.req.∠ : tan. M Take the diff. between ſide adj. req. angle and M, call it N. ſine N : ſine M :: tan. gn. angle : tan. req.∠	like or unlike ſide op. req. angl. as given angle is ac. or ob.

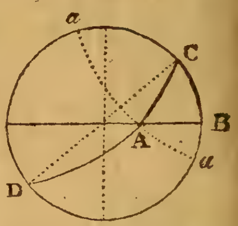
534.		and their included ∠	other ſide	Rad : coſ. gn. ang. : : tan. eith. gn.S. : tan. M Take the diff. between the other ſide and M, call it N. coſ. M : coſ. N : : coſ. S. 1ſt uſed : coſ. req. S.	lik. or unl. ſide uſed, as given angle is acute or obtuſe. like or unlike N, as given angle is acute or obtuſe.
535.	IV.	Two angles and their includ. ſide	either of oth. ſides	Rad : coſ. gn. ſide : : tan.∠op.req.S. : cot. m Take the diff. between ∠ adj. required ſide and m, call it n. coſ. n : coſ. m : : tan. gn. ſide : tan. req. S.	like or unlike angl. op. req. ſide, as given ſide is acute or obtuſe. like or unlike n, as the angle op. req. ſide is ac. or ob.
536.			oth. angle	Rad : coſ. gn. ſide : : tan. eith. gn.∠ : cot. m Take the diff. between the other angle and m, call it n. ſine m : ſine n : : coſ.∠ 1ſt uſed : coſ. req. ∠	like or unlike angle uſed, as given ſide is acute or obtuſe. like or unlike angle here uſed, as m is leſs or greater than oth. angl.
537.	V.	Three ſides	either angle	Call the ſides including the angle ſought E and F; the oppoſite ſide call G. Put D equal to diff. between E and F; Find the half ſum and half diff. of G and D. Then, To the Ar. Co. of Log. ſin. of E, add the Ar. Co. of Log. ſin. of F, And the Log. ſine of $\frac{1}{2}$ ſum of G and D; Alſo the Log. ſine of $\frac{1}{2}$ diff. of G and D. Take half the ſum of theſe four Logs. which ſeek among the log. ſines; And the degrees and minutes being doubled, will give the angle ſought.	
538.	VI.	Three angles	either ſide	Let the given angles be taken as the ſides of another triangle, obſerving to uſe the ſupplement of that angle oppoſite the ſide required. In this new triangle, find the angle oppoſite to that ſide where the ſupplement is uſed, by the precepts in Prob. V. Then will the ſupplement of the angle thus found be the ſide required.	

SECTION VIII.

The conſtruction and numeral ſolution of the caſes of right angled ſpheric triangles.

539. EXAM. I. In the right angled ſpheric triangle ABC.
Given the hypoth. AC = 64° 40′ } Required the reſt.
And one leg BC = 42 12 }

CONSTRUCTIONS.



1ſt. *To put the given leg on the primitive circle.*

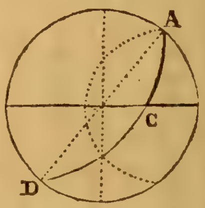
Deſcribe the primitive circle, and draw the right circle AB.

Apply the given leg (42° 12′) to the primitive circle from B to C.

About C as a pole, at a diſt. equal to the hyp. (64° 40′) (456) deſcribe a ſmall circle *aa*, cutting the right circle AB in A; and draw the right circle CD.

Thro' C, A, D, deſcribe an oblique circle. (163)

And ABC is the triangle ſought.



2. *To put the required leg on the primitive circle.*

Deſcribe the primitive circle, and draw the right circle CB; on which lay the given leg (42° 12′) from B to C. (446)

About C as a pole (454), at a diſtance equal to the hypoth. (64° 40′) deſcribe a ſmall circle, cutting the primitive in A; and draw AD.

Thro' A, C, D, deſcribe an oblique circle. (163)

Then ABC is the triangle required: Whoſe ſides and angles are meaſured by art. 446, 448.

COMPUTATIONS.

To find ∠ oppoſ. the giv. leg. (510)

As ſin. hyp.	= 64° 40′	0,04392
To Rad	= 90 00	10,00000
So ſin. gn. leg	= 42 12	9,82719
To ſin. op. ∠	= 48 00	9,87111

This angle is acute, becauſe it is to be like the given leg, which is acute.

To find ∠ adj. the given leg. (511)

As Rad	= 90° 00′	10,00000
To cot. hyp.	= 64 40	9,67524
So tan. gn. leg	= 42 12	9,95748
To coſ. adj. ∠	= 64 35	9,63272

This angle is acute, becauſe the hyp. and given legs are of like kinds.

To find the other leg. (512)

As coſ. gn. leg	= 42° 12′	0,13030
To Rad	= 90 00	10,00000
So coſ. hyp.	= 64 40	9,63133
To coſ. req. leg	= 54 43	9,76163

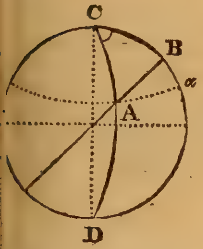
This leg is acute, becauſe the hyp. and given leg are of like kinds.

NOTE. In theſe operations, and in all the following ones; altho' the coſine, or cotang, are uſed in the proportions; yet the degrees and min. ſet down, are not the complements, but the real ſides or angles.

540. **Exam. II.** In the right angled ſpheric triangle ABC,
Given the hypoth. AC = 64° 40′ } Required the reſt.
And one angle ACB = 64 35 }

Constructions.

1ſt. *To put the leg adjacent to the given angle on the primitive circle.*



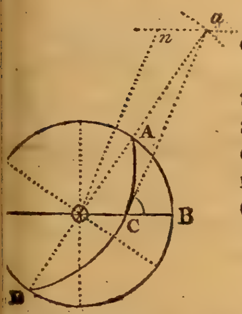
Thro' any point C, in the primitive circle, deſcribe (451) the oblique circle CAD, making with the primitive circle the angle BCA equal to the given angle 64° 35′.

In the oblique circle CAD, take CA, equal to the given hypothenuſe 64° 40′. (446)

Thro' A deſcribe the right circle AB.

And CAB is the triangle required.

2d. *To put the leg oppoſite the given angle on the primitive circle.*



Having deſcribed the primitive circle, and drawn the right circle OB.

Deſcribe (460) an oblique circle ACD, cutting the right circle OB in C, with the given angle 64° 35′, and having the part AC intercepted between the right circle OB and the primitive circle, equal to the given hypothenuſe 64° 40′

Then ABC is the triangle required.

The ſides required are meaſured by art. 446.

And the required angle by art. 448.

Computations.

o find the leg opp. the giv. ∠. (513)

A Rad	= 90° 00′		10,00000
T ſin. hyp.	= 64	40	9,95608
S ſin given ∠	= 64	35	9,95579
T ſin. op. leg	= 54	43	9,91187

ike the given angle.

To find the leg adj. the giv. ∠. (414)

As Rad	= 90° 00′		10,00000
To tan. hyp.	= 64	40	10,32476
So coſ. giv. ∠	= 64	35	9,63266
To tan. adj. leg	= 42	12	9,95742

Acute, as the hypoth. and given angle are of like kind.

To find the other angle. (515)

As Rad ———	= 90° 00′		10,00000
To coſ. hyp. ———	= 64	40	9,63133
So tan. given angle	= 64	35	10,32313
To cot. required angle	= 48	00	9,95446

nd is acute, as the hypoth. and given angle are of like kind.

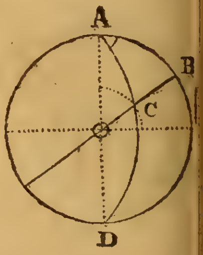
541.

541. Exam. III. In the right angled ſpheric triangle ABC.

Given one leg CB = 42° 12′ } Required the reſt.
And its opp. angle CAB = 48 00 }

Constructions.

1ſt. *To put the required leg on the primitive circle.*

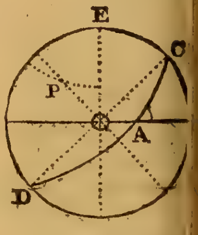


Deſcribe an oblique circle ACD (451), making with the primitive circle the angle CAB, equal to the given angle 48° 00′.

About the centre O of the primitive circle, deſcribe (455) a ſmall circle, at the diſtance of the complement of the given leg 42° 12′, cutting ACD in C.

Draw the right circle OCB, and ACB is the triangle ſought.

2d. *To put the given leg on the primitive circle.*



Draw the right circle OAB, and another OE at right angles.

Make BC equal to the given leg 42° 12′; draw the diameter CD, and another OP at right angles.

About E, the pole of AB, deſcribe a ſmall circle (456), at the diſtance of the given angle 48° 00′, cutting OP in P.

About P, as a pole (442), deſcribe the oblique circle CAD, cutting AB in A: Then is CBA the triangle required.

The ſides are meaſured by art. 446, and the angles by art. 448.

Computations.

To find the hypothenuſe.		(516)
As ſin. giv. ∠	= 48° 00′	0,12893
To ſin. giv. leg	= 42 12	9,82719
So Rad	= 90 00	10,00000
To ſin. hyp.	= 64 40½	9,95612

And is either acute or obtuſe.

To find the other leg.		(5
As Rad	= 90° 00′	10,000
To cot. giv. ∠	= 48 00	9,954
So tan. giv. leg	= 42 12	9,958
To ſin. req. leg	= 54 44	9,912

And is either acute or obtuſe.

To find the other angle.		(518)
As coſ. given leg	= 42° 12′	0,13030
To coſ. given ∠	= 48 00	9,82551
So Rad	= 90 00	10,00000
To ſin. required ∠	= 64 35	9,95581

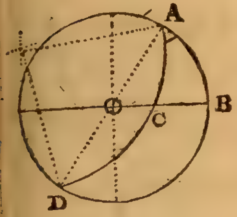
And is either acute or obtuſe.

542. EXAM. IV. In the right angled ſpheric triangle ABC.

Given a leg AC = 54° 43′ } Required the reſt.
And its adja. angle CAB = 48 00 }

CONSTRUCTIONS.

1ſt. *To put the given leg on the primitive circle.*



Having deſcribed the primitive, and right circle OB.

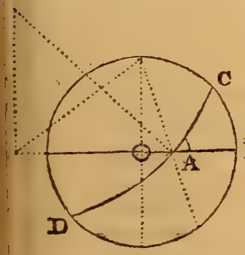
Make BA equal to the given leg 54° 43′.

Draw the diameter AD.

Thro' A deſcribe the oblique circle ACD (451) making with the primitive the given angle BAC 48° 00′, cutting OB in C.

Then is ACB the triangle required

2d. *To put the required leg on the primitive.*



In the right circle OB, take (447) AB, equal to the given leg 54° 43′.

Thro' the point A, deſcribe (452) the oblique circle CAD, making with AB the angle BAC, equal to the given angle 48° 00′, cutting the primitive circle in C.

Then is ABC the triangle ſought.

The ſides required are meaſured by art. 446.

And the required angle by art. 448.

COMPUTATIONS.

To find the other angle.		(519)
s Rad	= 90° 00′	10,00000
o coſ. giv. leg.	= 54 43	9,76164
o ſin. giv. ∠	= 48 00	9,87107
o coſ. req. ∠	= 64 35	9,63271

And is like the given angle.

To find the other leg.		(520)
As Rad	= 90° 00′	10,00000
To ſin. giv. leg	= 54 43	9,91185
So tan. giv. ∠	= 48 00	10,04556
To tan. req. leg	= 42 12	9.95741

And is like the given leg.

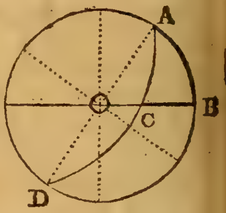
To find the hypothenuſe.		(521)
As Rad ———	= 90° 00′	10,00000
To coſ. given ∠ —	= 48 00	9,82551
So cot. given leg —	= 54 43	9,84979
To cot. hyp. ——	= 64 40	9,67530

And is acute, as the given leg and angle are of a like kind.

543. Exam. V. In the right angled ſpheric triangle ABC.
Given one leg BA = 54° 43′ } Required the reſt.
And the other leg BC = 42 12 }

Construction.

To put either leg on the primitive circle.



Having deſcribed the primitive circle, and drawn the right circle OB.

Then let the given legs 54° 43′, and 42° 12′, be applied, one from B to A, and the other from B to C (450); and draw the diameter AD.

Thro' the points A, C, D, deſcribe an oblique circle. (163)

Then is ABC the triangle required.

The angles A and C may be meaſured by art. 448.

And the hypothenuſe AC by art. 446.

Computations.

To find the angle A. (522)

As Radius		= 90°	00′	10,00000
To ſin. of leg	AB	= 54	43	9,91185
So cot. other leg	BC	= 42	12	10,04251
To cot. op. angle	A	= 48	00	9,95436

And is acute, as the oppoſite leg CB is acute.

To find the angle C. (522)

As Radius		= 90°	00′	10,00000
To ſin. of leg	CB	= 42	12	9,82719
So cot. other leg	AB	= 54	43	9,84979
To cot. op. angle	C	= 64	35	9,67698

And is acute, becauſe the oppoſite leg AB is acute.

To find the hypothenuſe AC. (523)

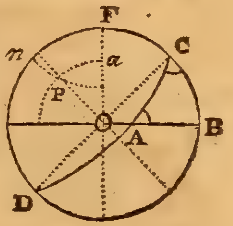
As Radius		= 90°	00′	10,00000
To coſ. either leg	AB	= 54	43	9,76164
So coſ. other leg	CB	= 42	12	9,86970
To coſ. hypoth.	AC	= 64	40	9,63134

And is acute, as the legs are of the ſame kind.

544. **Exam. VI.** In the right angled ſpheric triangle ABC.
Given one angle A = 48° 00′ }
And the other angle C = 64 35 } Required the reſt.

Construction.

To put either leg, as CB, *on the primitive circle.*



Having deſcribed the primitive circle, and drawn the right circle OB.

Then (461) deſcribe the oblique great circle CAD, cutting the primitive circle in the given angle C, and the right circle OB in the given angle A.

The ſides are to be meaſured by art. 446.

Computations.

To find the leg CB. (524)

As ſin. ∠ adj. req. leg, C	= 64° 35′	0,04421
To Radius ——	= 90 00	10,00000
So coſ other angle A	= 48 00	9,82551
To coſ. of its op. leg CB	= 42 12	9,86972

And is acute, becauſe the oppoſite ∠ is acute.

To find the leg AB. (524)

As ſin. ∠ adj. req. leg, A	= 48° 00′	0,12893
To Radius ——	= 90 00	10,00000
So coſ. other angle C	= 64 35	9,63266
To coſ. of its op. leg AB	= 54 43	9,76159

And is acute, becauſe the oppoſite ∠ is acute.

To find the hypothenuſe AC. (525)

As Radius ——	= 90° 00′	10,00000
To cot. either angle, as A	= 48 00	9,95444
So cot. other angle, as C	= 64 35	9,67687
To coſ. hypoth. AC	= 64 40	9,63131

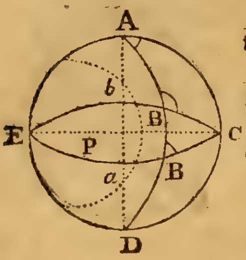
And is acute, becauſe the angles are both acute, or alike.

545. **Exam. VII.** In the quadrantal triangle ABC.

Given the quadrantal ſide AC = 90° 00′ }
An adjacent angle A = 42 12 } Required the reſt.
And the oppoſite angle B = 64 40 }

Construction.

To put the quadrantal ſide on the primitive circle.



Having deſcribed the primitive circle, and drawn the diameters AD, EC, at right angles.

Deſcribe the oblique circle ABD, making with AC an angle of 42° 12′. (451)

Thro' C deſcribe a great circle CBE, cutting the circle ABD in an ∠ of 64° 40′. (450)

Then is ABC the triangle ſought.

The angle C is to be meaſured by art. 448.

And the ſides AB, CB are meaſured by art. 446.

Computation.

Imagine the given triangle ABC to be changed into a right angled triangle, where the ſupplement of the angle B is to repreſent the hypothenuſe, and the angle A to be one of the legs.

Then will the ſolution fall under art. 510, 511, 512, in the table; and the numeral computations will be the ſame as in Ex. I. Obſerving that the angles there found are, in this example, the meaſures of the ſides AB, CB; and the ſide AB in that example ſtands for the angle C in this.

Now in determining the value of the parts of this triangle, as they ariſe in the computation; the words like and unlike are to be changed one for the other, where the hypothenuſe is concerned in the determination: Thus the leg AB is taken acute, becauſe the ſupplement of the angle oppoſite to the quadrantal ſide, which is here uſed as the hypothenuſe, is unlike to the other given angle; and its oppoſite angle C is to be acute for the ſame reaſon: But the kind of the ſide BC being known by the kind of its oppoſite angle A, it muſt be taken acute, as the oppoſite angle is acute.

In the conſtruction there ariſes two triangles, either of which will anſwer the conditions in the example: For the ſmall circle deſcribed about P, the pole of the oblique circle ABD, cuts the diameter AD in the points *a*, *b*; and either of theſe points may be taken for the pole of the oblique circle wanting to compleat the triangle.

Now if *a* be taken for the pole, then in the triangle ABC, the meaſure of the things ſought, will be equal to thoſe ariſing from the computation: But the angle B is the ſupplement of what is given.

And if *b* is taken for the pole; then the triangle ABC will ariſe from the conſtruction; wherein the angles A and B are reſpectively equal to what is propounded: But then the ſide AB, and the angle C, will both be obtuſe.

SECTION IX.

The conſtruction and numeral ſolution of the caſes of oblique angled ſpheric triangles.

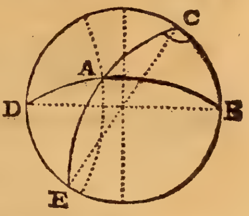
546. EXAM. I. In the oblique angled ſpheric triangle ABC.

Given the ſide AB = 114° 30′ }
the ſide BC = 56 40 } Required the reſt.
And an angle oppoſite to one ſide BCA = 125 20 }

CONSTRUCTION.

To put the given ſide, adjacent to the known angle, on the primitive circle.

Deſcribe the primitive circle, and draw the dimeter BD.



Make BC equal to the ſide adjacent to the given ngle = 56° 40′. (446)

Deſcribe the great circle CAE, making the angle CA equal to the given one, = 125° 20′. (451)

Thro' B deſcribe a great circle BAD, cutting AE in A, at the diſtance of AB the other given de from B, = 114° 30′. (456)

Then ABC is the triangle ſought.

And the parts required are meaſured by art. 446, 448.

COMPUTATIONS.

To find the angle A, *oppoſite to the other given ſide.* (527)

As ſin. one ſide AB	= 114° 30′	0,04098
To ſin. op. ∠ C	= 56 40	9,92194
To ſin. oth. ſide CB	= 125 20	9,91158
To ſin. op. ∠ A	= 48 31	9,87450

Which may be either acute or obtuſe from the things given: But the conſtruction ſhews it to be acute.

To find the angle B *between the given ſides.* (528)

As Rad	= 90° 00′	10,00000
To tan. giv. ∠ C	= 125 20	10,14941
To coſ. adj. ſid. BC	= 56 40	9,73997
To cot. m	= 127 46	9,88938

And is obtuſe, as the given angle nd its given adjacent ſide are unlike.

As cot. S. ad. g. ∠, BC	= 56° 40′	0,18196
To cot. oth. ſide AB	= 114 30	9,65870
So coſ. m	= 127 46	9,78707
To coſ. n	= 64 54	9,62773

Which is acute, being unl. ſide opp. given ∠, that ∠ being obtuſe.

Then as the given ſides are unlike, the diff. of m and n, or 62° 52′ = ∠ B.

To find the other ſide AC. (529)

As Rad	= 90° 00′	10,00000
To coſ. giv. ∠ C	= 125 20	9,76218
To tan. adj. ſid. BC	= 56 40	10,18196
To tan. M	= 138 41	9,94414

nd is obtuſe, as ∠ C and CB are unlike.

As coſ. S. ad. g. ∠, BC	= 56° 40′	0,26002
To coſ. oth. ſid. AB	= 114 30	9,61773
So coſ. M	= 138 41	9,87568
To coſ. N	= 55 28	9,75343

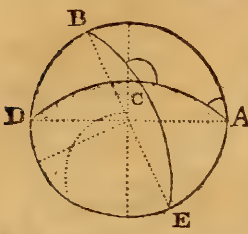
And is acute, being unl. AB, as above.

Then as BC and BA are unlike, the diff. of M and N, or 83° 13′ = AC.

547. Exam. II. In the oblique angled ſpheric triangle ABC.
Given the angle BAC = 48° 31′
the angle BCA = 125 20
And the ſide oppoſite to one angle, AB = 114 30
} Required the reſt.

Construction.

To put the given ſide AB *on the primitive circle.*



Deſcribe the primitive circle, draw the diameter DA; and thro' A deſcribe the great circle ACD making the given angle BAC = 48° 31′. (451

Make the arc AB equal to the given ſide = 114° 30′ (446); and draw the diam. BE.

Thro' B, deſcribe the great circle BCE, cutting ACD in an angle equal to the given angle BCA = 125° 20′. (458

Then is ACB the triangle ſought.

And the parts required are to be meaſured by art. 446, 448.

Computation.

To find the ſide oppoſite the other given angle. (530)

As ſin. one ∠ C	=125°	20′	0,08841
To ſin. op. ſide AB	=114	30	9,87457
So ſin. oth. ∠ A	= 48	31	9,95902
To ſin. op. ſide BC	= 56	40	9,92200

Which may be either acute or ob tuſe from what is given. But the con ſtruction ſhews it to be acute.

To find the ſide AC *between the given angles.* (531)

As Rad	= 90°	00′	10,00000
To coſ. ∠ ad. g. S. A	= 48	31	9,82112
So tan. gn. S. AB	=114	30	10,34129
To tan. M	=124	32	10,16241

And is obtuſe, being unlike ∠ A, as AB is greater than 90′.

As cot ∠ ad. g. S. A	= 48°	31′	0,0534
To cot. oth. ∠ C	=125	20	9,8505
So ſine M	=124	32	9,9158
To ſine N	= 41	20	9,8198

Which may be either acute or ob tuſe; either 41° 20′, or 138° 40′.

Then as the given angles are unlike, the diff. of M and N, or 83° 12′, is th ſide AC.

To find the other angle ABC. (532)

As Rad	= 90°	00′	10,00000
To tan. ∠ ad. g. S. A	= 48	31	10,05319
So coſ. g. ſide AB	=114	30	9,61773
To cot. m	=115	07	9,67092

And is obtuſe, being unlike ∠ A, as its adj. ſide AB is greater than 90°.

As coſ. ∠ ad. g. S. A	= 48°	31′	0,1788
To coſ. oth. ∠ C	=125	20	9,7621
So ſine m	=115	07	9,9568
To ſine n	= 52	14	9,8979

Which may be either acute or ol tuſe.

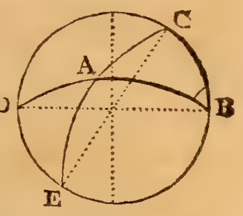
Then as the given angles are unlike, the diff. of m and n, or 62° 53′, is th angle B required.

548. Exam. III. In the oblique angled ſpheric triangle ABC.

Given the ſide AB = 114° 30′
the ſide BC = 56 40 } Required the reſt.
And the contained angle ABC = 62 52

Construction.

To put either of the given ſides, as BC, *on the primitive circle.*



Deſcribe the primitive circle, draw the diameter BD; and thro' B deſcribe a great circle BAD, making the given angle ABC = 62° 52′. (451)

On the circles BCD, BAD, take the arcs BC, BA, reſpectively equal to the given ſides, *viz.* BC = 56° 40′, and BA = 114° 30′. (446)

Draw the diameter CE, and thro' C, A, E, deſcribe the great circle CAE; then ABC is the triangle ſought.

The required parts of ABC are meaſured by art. 446, 448.

Computation.

To find the angle C. (533)

As Rad	= 90° 00′	10,00000	Obtuſe, being like ſide op. req. ∠; The given angle being acute. Take the diff. between M and BC, and 'tis 78° 19′, call it N.
To coſ. gn. ∠ B	= 62 52	9,65902	
So t. S.op.re.∠ AB	= 114 30	10,34129	
To tan. M	= 134 59	10,00031	

As ſine N	= 78° 19′	0,00909	And is obtuſe, being unlike the given angle, becauſe M is greater than BC, the ſide adjacent to the required angle.
To ſine M	= 134 59	9,84961	
So tan. gn. ∠ B	= 62 52	10,29034	
To tan. req. ∠ C	= 125 21	10,14904	

To find the angle A. (533)

As Rad	= 90° 00′	10,00000	Acute, being like ſide op. req. ∠. The given angle being acute. Take the diff. between M and BA, and 'tis 79° 46′, call it N.
To coſ. gn. ∠ B	= 62 52	9,65902	
So t. S.op.re.∠ BC	= 56 40	10,18196	
To tan. of M	= 34 44	9,84098	

As ſine N	= 79° 46′	0,00696	And is acute, being like the given angle, as M is leſs than AB, the ſide adjacent to the required angle.
To ſine M	= 34 44	9,75569	
So tan. gn. ∠ B	= 62 52	10,29034	
To tan. req. ∠ A	= 48 29	10,05299	

To find the other ſide AC. (534)

As Rad	= 90° 00′	10,00000	As coſ. M	= 134° 59′	0,15304
To coſ. gn. ∠ B	= 62 52	9,65902	To coſ. N	= 78 19	9,30643
So tan. eith. S. AB	= 114 30	10,34129	So coſ. S. uſed AB	= 114 30	9,61773
To tan. M	= 134 59	10,00031	To coſ. S. req. AC	= 83 11	9,07480

Obtuſe, being like AB the ſide uſed, becauſe the given angle is acute.

And is acute, being like N; becauſe the given angle is acute.

Then the diff. M and BC, or 78° 19′ = N.

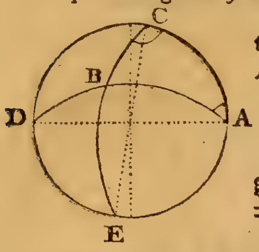
549.

549. EXAM. IV. In the oblique angled ſpheric triangle ABC.

Given the angle BCA = 125° 20′
the angle BAC = 48 31 Required the reſt.
And the included ſide AC = 83 13

CONSTRUCTION.

To put the given ſide on the primitive circle.



Deſcribe the primitive circle, draw the diameter AD; and thro' A deſcribe the great circle ABD, making the given ∠BAC = 48° 31′. (451)

Make AC equal to the given ſide = 83° 13′. (446)

Draw the diameter CE, and thro' C deſcribe the great circle CBE, making the given angle BCA = 125° 20′ (451), cutting ABD in B.

Then is ABC the triangle ſought.

And the parts required are meaſured by art. 446, 448.

COMPUTATION.

To find the ſide AB. (535)

As Rad =	90° 00′	10,00000
To coſ. gn. ſide AC =	83 13	9,07230
So tan. ∠op.r.S.C =	125 20	10,14941
To cot. m. =	99 28	9,22171

Obtuſe, being like ∠ op. ſide req the given ſide being acute.
Take the diff. between m and ∠ A and it is 50° 57′; call it n.

As coſ. n =	50° 57′	0,20066
To coſ. m =	99 28	9,21610
So tan. gn. ſid. AC =	83 13	10,92464
To tan. req. ſid. AB =	114 30	10,34140

And is obtuſe, being unlike n, becauſ the angle oppoſite to the ſide require is obtuſe.

To find the ſide BC. (535)

As Rad =	90° 00′	10,00000
To coſ. gn. ſid. AC =	83 13	9,07230
So tan. ∠op.r S.A =	48 31	10,05345
To cot. of m =	82 23	9,12575

Acute, being like ∠ op. ſide required the given ſide being acute.
Take the diff. between m and ∠ C and 'tis 42° 57′, call it n.

As coſ. n =	42° 57′	0,13552
To coſ. m =	82 23	9,12236
So tan. gn. ſid. AC =	83 13	10,92464
To tan. req ſid. BC =	56 41	10,18252

And is acute; being like n; becauſ the angle A oppoſite to BC, the ſid required, is acute.

To find the other angle B. (536)

As Rad =	90° 00′	10,00000
To coſ. gn. ſid. AC =	83 13	9,07230
So tan. eith. ∠ C =	125 20	10,14941
To cot. m =	99 28	9,22171

Obtnſe, being like ∠ C here uſed: Becauſe the given ſide is acute.

Take diff. of m and ∠ A, *viz.* 42° 57′, and call it n.

As ſin. m =	99° 28′	0,0059
To ſine n =	50 57	9,8901
So coſ. ∠ uſed, C =	125 20	9,7621
To coſ. req. ∠ B =	62 53	9,6583

And is acute, being unlike the angl C here uſed, as m is greater than th other angle A.

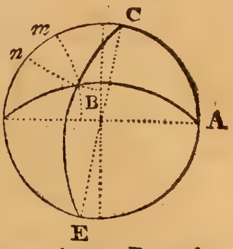
550

550. **Exam. V.** In the oblique angled ſpheric triangle ABC.

Given the ſide AB = 114° 30′ }
the ſide AC = 83 13 } Required the reſt.
the ſide BC = 56 40 }

Construction.

To put either ſide, as AC, *on the primitive circle.*



Deſcribe the primitive circle, and from any oint in the circumference, as A, ſet off one of 1e given ſides, as AC, = 83° 13′ (446); and raw the diameters AD, CE.

About C, as a pole, and at a diſtance equal to he given ſide BC, = 56° 40′, deſcribe a ſmall ircle *n* B. (456)

About A, as a pole, and at a diſtance equal to 1e given ſide AB (when AB is leſs than 90°) deribe another ſmall circle *m* B (456), cutting the former in B: But when 1e ſide, as AB = 114° 30′, is greater than 90°; then about D, the opoſite pole to A, deſcribe a ſmall circle with the ſupplement of AB, as B, cutting the former ſmall circle *n* B in B.

Thro' the points A, B, D, and C, B, E, deſcribe the great circles ABD, CBE. hen is ABC the triangle ſought. And the angles are meaſured by art. 448.

Computation.

To find the angle C. (527.

ere AC = E = 83°13′
CB = F = 56 40
AB = G = 114 30
E — F = D = 26 33
G + D = 141 03 | 70°31½′ = ½ ſum
G — D = 87 57 | 43 58½ = ½ diff.

Ar. Co. ſin. E	= 83° 13′		0,00305
Ar. Co. ſin. F	= 56 40		0,07806
Sin ½ ſum	= 70 31½		9,97441
Sin. ½ diff.	= 43 58½		9,84158
Sum of the four Logs			19,89710
½ ſum gives 62° 39½′			9,94855

Which doubled gives 125°10′ = ∠C.

To find the angle A. (527)

ere AB = E = 114°30′
AC = F = 83 13
BC = G = 56 40
E — F = D = 31 17
G + D = 87 57 | 43°58½′ = ½ ſum
G — D = 25 23 | 12 41½ = ½ diff.

Ar. Co. ſin.	E = 114° 30′		0,04098
Ar. Co. ſin.	F = 83 13		0,00305
Sin. ½ ſum	= 43 58½		9,84158
Sin. ½ diff.	= 12 41½		9,34184
Sum of four Logs			19,22745
½ ſum gives 24° 15½′			9,61372

Which doubled gives 48° 31′ = ∠ A.

To find the angle B. (527)

ere AB = E = 114°30′
BC = F = 56 40
AC = G = 83 13
E — F = D = 57 50
G + D = 141 03 | 70°31½′ = ½ ſum
G — D = 25 23 | 12 41½ = ½ diff.

Ar. Co. ſin. E	= 114° 30′		0,04098
Ar. Co. ſin. F	= 56 40		0,07806
Sin. ½ ſum	= 70 31½		9,97441
Sin ½ diff.	= 12 41½		9,34184
Sum of four Logs			19,43529
½ ſum gives 31° 28′			9,71764

Which doubled gives 62° 56′ = ∠ B.

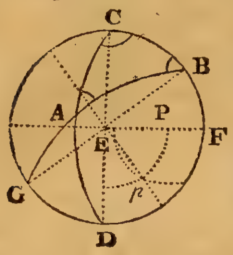
551.

551. **Exam. VI.** In the oblique angled ſpheric triangle ABC.

Given the angle A = 48° 31′
the angle B = 62 52
the angle C = 125 20
} Required the reſt.

Construction.

To put either two angles, as C *and* B, *at the primitive circle.*



Deſcribe the primitive circle, draw the diameter CD and EF at right angles to one another; and thrc C deſcribe a great circle CAD, making the angl BCA equal to the given angle C = 125°20′ (451

Deſcribe a great circle BAG, cutting the give great circles CFD, CAD, in the given angles = 62° 52′, and A = 48° 31′. (461

Then is ABC the triangle ſought.

Wherein the ſides are meaſured by art. 446.

Computation.

To find the ſide AB. (528)

Here ∠B = E = 62°52′
∠A = F = 48 31
Sup. ∠C = G = 54 40
E − F = D = 14 21
G + D = 69 01 | 34°30½′ = ½ ſum
G − D = 40 19 | 20 09½ = ½ diff.

Ar. Co. ſin. E	= 62° 52′	0,0506
Ar. Co. ſin. F	= 48 31	0,1254
Sin. ½ ſum	= 34 30½	9,7532
Sin. ½ diff.	= 20 09½	9,5373
Sum of the four Logs		19,4666
½ ſum gives 32° 45½′		9,7333

The ſup. of its double is 114°29′ = AI

To find the ſide AC. (528)

Here ∠C = E = 125°20′
∠A = F = 48 31
Sup. ∠B = G = 117 08
E − F = D = 76 49
G + D = 193 57 | 96°58½′ = 2 ſum
G − D = 40 19 | 20 09½ = ½ diff.

Ar. Co. ſin. E	= 125° 20′	0,0884
Ar. Co. ſin. F	= 48 31	0,1254
Sin. ½ ſum	= 96 58½	9,9967
Sin. ½ diff.	= 20 09½	9,5373
Sum of four Logs		19,7479
½ ſum gives 48° 25½′		9,8739

The ſup. of its double is 83° 09′ = C

To find the ſide BC. (528)

Here ∠C = E = 125°20′
∠B = F = 62 52
Sup. ∠A = G = 131 29
E − F = D = 62 28
G + D = 193 57 | 96°58½′ = ½ ſum
G − D = 69 01 | 34 30½ = ½ diff.

Ar. Co. ſin. E	= 125° 20′	0,088
Ar. Co. ſin. F	= 62 52	0,050
Sin. ½ ſum	= 96 58½	9,996
Sin. ½ diff.	= 34 30½	9,753
Sum of four Logs		19,889
½ ſum gives 61° 39′		9,9445

The ſup. of its double is 56° 42′ = B

THE ELEMENTS OF NAVIGATION.

BOOK V.

OF GEOGRAPHY.

SECTION I.

Definitions and *Principles.*

52. GEOGRAPHY is the art of deſcribing the figure, magnitude, and poſitions of the ſeveral parts of the ſurface of the earth.

553. The EARTH is a ſpherical or globular figure *; and is uſually lled the terraqueous globe.

554. There are two points on the ſurface of the terraqueous globe, lled the POLES OF THE EARTH, which are diametrically oppoſite to e another; one is called the *north pole*, and the other, the *ſouth pole.*

---

* For in ſhips at ſea, the firſt parts of them that become viſible are the upper ils; and as they approach nearer, the lower ſails appear; and ſo on, until ey ſhew their hulls.

Alſo ſhips, in ſailing from high capes or head lands, loſe ſight of thoſe eminences gradually from the lower parts, until the top vaniſhes.

Now as theſe appearances are the objects of our ſenſes in all parts of the th,

Therefore the ſurface of the earth muſt be convex.

And this convexity is, at ſea, obſerved to be every where uniform.

But a body, whoſe ſurface is every where uniformly convex, is a globe.

Therefore the figure of the earth is globular.

In order to deſcribe the poſitions of places, Geographers have found it neceſſary to imagine certain circles drawn on the ſurface of the earth, to which they have given the names of Equator, Meridian, Horizon, Parallels of latitude, *&c.*

555. The EQUATOR is a great circle on the earth, equally diſtant from each pole, dividing the terraqueous globe into two equal parts; one called the *northern hemiſphere*, in which is the north pole; and the other containing the ſouth pole, is called the *ſouthern hemiſphere.*

556. MERIDIANS are imaginary circles on the earth, paſſing thro' both the poles, and cutting the equator at right angles.

Every point on the ſurface of the earth has its proper meridian.

557. LATITUDE is the diſtance of a place from the equator, reckoned in degrees and parts of degrees on a meridian.

On the north ſide of the equator it is north latitude; and on the ſouth ſide it is ſouth latitude.

As latitude begins at the equator, where it is nothing; ſo it ends at the poles, where the latitude is greateſt, or 90 degrees.

558. PARALLELS OF LATITUDE are circles parallel to the equator. Every place on the earth has its parallel of latitude.

DIFFERENCE OF LATITUDE is an arc of a meridian, or the leaſt diſtance of the parallels of latitude of two places; ſhewing how far one of them is to the northward, or ſouthward of the other.

The difference of latitude can never exceed 180 degrees.

559. In north latitudes, if about the middle of the months of March and September, a perſon looks towards the ſun at noon, the ſouth is before him, the north behind; the weſt on the right hand, and the eaſt on the left: And in ſouth latitudes, if the face is turned towards the ſun, at the ſame times, the north is before, the ſouth behind, the eaſt to the right, and the weſt on the left.

In latitudes greater than 23½ degrees, theſe poſitions found at noon, will hold good on any day of the year.

560. LONGITUDE of any place on the earth is expreſſed by an arc o the Equator, ſhewing the eaſt or weſt diſtance of the meridian of tha place from ſome fixed meridian where longitude is reckoned to begin.

561. DIFFERENCE OF LONGITUDE is an arc of the equator inter-cepted between the meridians of two places, ſhewing how far one o them is to the eaſtward, or weſtward of the other.

As longitude begins at the meridian of ſome place, and is counte from thence both eaſtward and weſtward, till they meet at the ſam meridian on the oppoſite point; therefore the difference of longitude ca never exceed 180 degrees.

562. When two places have latitudes both north, or both ſouth; o have longitudes both eaſt, or both weſt; they are ſaid to be of the ſame or of like name: But when one has north latitude, and the other ſouth or if one has eaſt longitude, and the other weſt, then they are ſaid t have contrary, or different, or unlike names.

563. The HORIZON is that apparent circle which limits, or bound the view of a ſpectator on the ſea, or on an extended plain; the eye o the ſpectator being always ſuppoſed in the centre of his horizon.

Whe

When the ſun or ſtars come above the eaſtern part of the horizon, they are ſaid to riſe; and when they deſcend below the weſtern part, they are ſaid to ſet.

When a ſhip is under the equator, both the poles appear in the horizon; and in proportion as ſhe ſails towards either, or increaſes her latitude, that pole is ſeen proportionally higher above the horizon, and the other diſappears as much: But when a ſhip is ſailing towards the equator, or decreaſes her latitude, ſhe depreſſes the elevated pole; that is, its diſtance from the horizon decreaſes.

Of the diviſion of the earth into Zones.

564. A ZONE is a broad ſpace on the earth, included between two arallels of latitude.

There are five zones; namely, one *Torrid*, two *Frigid*, and two *Temperate*: Theſe names ariſe from the quality of the heat and cold to which their ſituations are liable.

565. The TORRID ZONE is that portion of the earth, over every part of which the ſun is perpendicular at one time of the year or other.

This zone is about 47 degrees in breadth, extending to about 23½ legrees on each ſide of the equator; the parallel of latitude terminating he limits in the northern hemiſphere is called the *Tropic of Cancer*; nd in the ſouthern hemiſphere, the limiting parallel is called the *Tropic f Capricorn.*

566. The FRIGID ZONES are thoſe regions about the poles where he ſun does not riſe for ſome days, nor ſet for ſome days of the year.

Theſe zones extend round the poles to the diſtance of about 23½ degrees: That in the northern hemiſphere is called the north frigid zone, nd is bounded by a parallel of latitude called the *Artic polar circle*; and he other in the ſouthern hemiſphere, the ſouth frigid zone, the parallel f latitude bounding it being called the *Antartic polar circle.*

567. The TEMPERATE ZONES are thoſe ſpaces between the Torrid nd the Frigid zones.

Of the diviſion of the earth by Climates.

568. A CLIMATE, in a geographical ſenſe, is that ſpace of the earth ontained between two parallels of latitude, where the difference beween the longeſt day in each parallel is half an hour.

Theſe climates are narrower the farther they are from the equator; herefore, ſuppoſing the equator the beginning of the firſt climate, the olar circle will be the end of the 24th climate; for afterwards the longeſt ay increaſes not by half hours, but by days and months.

SECTION II.

Of the natural diviſion of the Earth.

569. By the natural diviſion of the earth is meant the parts on its ſurface formed by nature; ſuch as *Continents*, *Oceans*, *Iſlands*, *Seas*, *Rivers*, *Mountains*, &c.

The ſurface of the earth is naturally divided into Land and Water.

Land is divided into
1. Continents.
2. Iſlands.
3. Peninſulas.
4. Iſthmus's.
5. Promontories.
6. Mountains.

Water is divided into
1. Oceans.
2. Seas.
3. Gulfs.
4. Straits.
5. Lakes.
6. Rivers.

570. A CONTINENT, or, as it is frequently called, the *Terra Firma*, or *main land*, is a very large tract, comprehending ſeveral contiguous Countries, Kingdoms and States.

571. An OCEAN is a vaſt collection of ſalt-water, ſeparating the continents from one another, and waſhing their borders or ſhores.

572. An ISLAND is a part of dry land ſurrounded with water.

573. A SEA is a branch of the Ocean, flowing between ſome parts of the continent, or ſeparating an Iſland from the Continent.

574. A PENINSULA is a part of dry land encompaſſed by water, except a narrow neck which joins it to ſome other land.

575. An ISTHMUS is the neck joining the peninſula to the adjacent land, and forms the paſſage between them.

576. A MOUNTAIN is a part of the land more elevated than the adjacent country, whereby it is ſeen at a greater diſtance than the neighbouring lower lands.

577. A PROMONTORY is a mountain ſtretching itſelf into the ſea; the extremity whereof is called a *Cape*, or *Head-land*.

578. A HILL is a ſmall kind of mountain: A *Cliff* is a ſteep ſhore hill, or mountain: And *Rocks* are great ſtones riſing like hills above the dry land, or above the bottom of the ſea.

579. A GULF or BAY is a part of the Ocean or Sea contained between two ſhores; and is every where environed with land except its entrance, where it communicates with other Bays, Seas or Oceans.

580. A STRAIT is a narrow paſſage, by which there is a communication between a Gulf and its neighbouring ſea, or joining one part o the ſea or ocean with another.

581. A LAKE is a collection of Waters contained in ſome hollow or cavity in an inland place, of a large extent, and every where ſurrounded with land; having no viſible communication with the Ocean.

582. RIVERS are ſtreams of Water flowing chiefly from the Mountains, and running in long narrow channels or cavities thro' the land till they either fall into the ſea, or into other rivers, which at laſt diſembogue or run into the ſea.

583. There are generally reckoned four Continents, namely, EUROPE, ASIA, AFRICA, and AMERICA.

To theſe may be added two others, one called the *Terra artica*, or northern continent, and the other the *Terra antartica*, or ſouthern continent.

The continent of *America* is uſually divided into two parts, called *north* and *ſouth America*.

The *Terra artica*, with *Europe* and *Aſia*, lie all within the northern hemiſphere; and alſo parts of *Africa* and *America*: The other parts of heſe two continents, together with the *Terra antartica*, lie in the ſouhern hemiſphere.

584. There are five Oceans, namely, the NORTHERN, the ATLANTIC, the PACIFIC, the INDIAN and the SOUTHERN.

The *Atlantic ocean* is uſually divided into two parts, one called the *north Atlantic ocean*, and the other the *ſouth Atlantic*, or *Ethiopic* ocean.

The *Northern ocean* ſtretches to the northward of Europe, Aſia and America, towards the north pole.

The *Atlantic ocean* lies between the continents of Europe and Africa n the eaſt, and America on the weſt.

That part of the north Atlantic ocean lying between Europe and America is frequently called the *Weſtern ocean*.

The *Pacific ocean*, or, as it is ſometimes called, the *South Sea*, is bounded by the weſtern and north weſt ſhores of America, and by the eaſtern and north eaſt ſhores of Aſia.

The *Indian ocean* waſhes the ſhores of the eaſtern coaſts of Africa, nd the ſouth of Aſia; and is bounded on the eaſt by the Indian iſlands nd the ſouthern continent.

The *Southern ocean* extends to the ſouthward of Africa and America oward the ſouth pole.

The northern and ſouthern continents not being ſufficiently known o Geographers; all that need be ſaid of them, is, that the Terra Artica, r land to the northward of Hudſon's bay and Greenland, is too cold for he reſidence of mankind; and that part which is known of the Terra Antartica, namely, New Guinea, New Holland, &c. appears to be very arren, and the natives very little ſuperior to brutes.

SECTION III.

Of the Political diviſion of the Earth.

585. By the political diviſion of the earth, is meant the differen Countries, Empires, Kingdoms, States, and other denominations eſtabliſhed by men, either by the ambition of tyrants, or for the ſake o good government.

OF EUROPE.

Europe is bounded on the north by the northern or frozen ocean; or the eaſt by Aſia; on the ſouth by the Mediterranean ſea, ſeparating Europe from Africa; and by the north Atlantic or weſtern ocean on th weſt: It lies between the latitudes of 36 and 72 degrees of north latitude; and between the longitudes of 10 degrees weſt, and 65 degrees eaſ from London; is about 3000 miles long, reckoning from the N. E. t the S. W. and about 2500 miles broad.

586. The countries, their poſition with regard to the middle parts o Europe, the chief cities, principal rivers with their courſes, and the moſ noted mountains, and what quarter of the country they are in, are exhibited in the following table; where E ſtands for empire, K for kingdom, R for republic, Nd. for northward, *&c.*

Countries.	Poſition.	Chief Cities.	Rivers.	Courſe.	Mountains.	
E. Turky	S. E.	Conſtantinople	Danube	E.	Argentum	Nd.
K. Poland	Mid.	Warſaw	Viſtula	N. N. W	Carpathian	Sd.
E. Muſcovy	N. E.	Moſcow	Wolga	E. to S.	Boglowy	Sd.
		Peterſburg	Neiper	S.	Riphean	Nd.
K. Sweden	N.	Stockholm	Dalecarlia	E.	Dofrine	Wd.
K. Norway	N. N. W.	Bergen	Glama	S.	Dofrine	Ed.
K. Denmark	N. W.	Copenhagen				
K. Hungary	Mid.	Preſburg	Danube	S. E.	Carpathian	Nd.
E. Germany	Mid.	Vienna	Danube	E.	Alps	Sd.
Italy	S.	Rome	Po	E.	Alps	Nd.
			Tyber	S.	Apennine	Mid.
R. Switzerland	Mid.	Bern	Rhine	W.	Alps	Sd
Netherlands	W.	Bruſſels	Maeſe	N.		
R. Dutchland	W.	Amſterdam	Rhine	N. N. W.		
K. France	W.	Paris	Loire	N. to W.	Pyrenees	S.W
			Rhone	S.	Alps	Ed
K. Spain	S.	Madrid	Tagus	W.	Pyrenees	N. E
K. Portugal	S. W.	Liſbon	Tagus	W.	C. Rocca	W.
K. England	W.	London	Thames	E.	Malvern	N.W
K. Scotland	W.	Edinburg	Forth	E.	Grampian	Nd
K. Ireland	W.	Dublin	Shannon	S. W.	Knockpatric	W.

There are in Europe four Kingdoms beſide thoſe enumerated above but they are contained in the forenamed Countries.

The Kingdom of Pruſſia, which is part of Poland; the King's reſidence is at Berlin a city in Germany.

Th

The Kingdom of Bohemia, a part of Germany; the ch. city is Prague.

The Kingdom of Sardinia, an Italian iſland; the king reſides at Turin city in Italy.

The Kingdom of the Sicilies, appending to Italy; the king reſides at aples a city in Italy.

In ſome of the forenamed countries, are ſeveral dominions, independ-nt one of the other; particularly in Germany and Italy.

The principal ſtates in Germany are the following 12: Where D ands for dutchy, El. for electorate, P for principality.

ates	D. Auſtria	K. Bohemia	El. Bavaria	El. Brandenburg
h. cities	Vienna	Prague	Munich	Berlin
ates	El. Saxony	El. Hannover	El. Palatine	El. Mentz
h. cities	Dreſden	Hannover	Manheim	Mentz
ates	El. Triers	El. Cologne	P. HeſſeCaſſel	D. Wurtemburg
h. cities	Triers	Cologne	Caſſel	Stutgard

The principal ſtates in Italy are the following 12.

ates	D. Savoy	P. Piedmont	D. Milaneſe	D. Parmeſan
1. cities	Chamberry	Turin	Milan	Parma
ates	D. Modeneſe	D. Mantuan	R. Venice	R. Genoa
1. cities	Modena	Mantua	Venice	Genoa
ates	D. Tuſcany	Patriarchate	R. Lucca	K. Naples
1. cities	Florence	Rome	Lucca	Naples

The principal Seas, Gulfs and Bays in Europe, are

587. The *Mediterranean Sea*, having Europe on the N. and Africa on e S.

The *Adriatic Sea*, between Italy and Turky.

The *Euxine* or *Black Sea* in Turkey, between Europe and Aſia.

The *White Sea* in the N. N. W. parts of Muſcovy.

The *Baltic Sea* between Sweden, Denmark and Poland.

The *German Ocean*, or Sea, between Germany and Britain.

The *Engliſh Channel* between England and France.

The *Bay of Biſcay* formed between France and Spain.

The *Gulf of Bothnia* in the N. E. parts of Sweden.

The *Gulf of Finland* between Sweden and Ruſſia.

The *Gulf of Venice*, the N. W. end of the Adriatic ſea.

The principal Iſlands in Europe, are

588. The *Britiſh Iſles*, viz. Great Britain, Ireland, Orkneys and eſtern Iſles.

The *Spaniſh Iſles*; Majorca, Minorca, Ivica, in the Medit. ſea.

Italian Iſles; Sicily, Sardinia, Corſica, Lipari, in the Medit. ſea.

Turkiſh Iſles; Candia, Archipelago Iſles, in the Medit. ſea.

Swediſh Iſles; Gothland, Oeland, Alan, Rugen, in the Baltic ſea.

Daniſh Iſles; Zeland in the Baltic ſea; and Iſeland, Faro Iſles, E. and W. Greenlands in the Northern ocean.

Azores Iſles in the Atlantic ocean.

OF ASIA.

589. The continent of Aſia is bounded on the north by the Norther or frozen ocean, on the eaſt by the Pacific ocean, on the ſouth by th Indian ocean, and by Africa and Europe on the weſt: It lies, including its Iſlands, between the latitudes of 10 degrees ſouth, and 72 degrees north; and is between the longitudes of 25 and 148 degrees eaſt o London: Its length, excluſive of the iſles, being about 4800 miles, an breadth about 4300 miles.

590. The poſitions and names of the chief countries, cities, river and mountains, are contained in the following table.

Countries.	Poſition.	Chief Cities.	Rivers.	Courſe.	Mountains.
E. China	S. E.	Pekin	Yellow R.	S. to E.	Ottorocoran Nd
		Nankin	Kiam	E.	Damaſian Wd
		Canton	Ta	S. E.	
K. Korea	E.	Kingkitau	Yalu	S.	Shanalin
ChineſeTartary	E.	Chynian	Yamour	N.E. to E.	Fongwhanſhan
Mongalia	Mid.	Kudak	Yellow R	N. to W.	
K. Thibet	Mid.	Eſkerdu	Yaru	E.	Kantes
Bukharia, or Uſbecs	Mid.	Samarkand	Amu	N. W.	Belurlag
Karazm	Mid.	Urjenz	Amu	S.W.	Irder
Kalmucks	Mid.		Tekis		Tubratubuſluk
E. Siberia	N.	Tobolſki	Oby	N.	Stolp
		Aſtracan	Jeniſka	N. N. W.	
E. Turky	W.	Smyrna	Euphrates	S. E.	Taurus
K. Syria	W.	Aleppo	Euphrates	S.	Lebanon
Arabia	S. W.	Medina	Euphrates	S. E.	Gabel el ared
E. Perſia	S.	Iſpahan	Oxus	W.	Caucauſus
			Araxes	S.W.	Taurus
India Wſt. the Ganges	S.	Agra	Indus	S.W.	Caucauſus
		Delli	Ganges	S.W.	Balagate
India Eaſt the Ganges	S.	Ava	Domea	S.	Damaſcene
		Pegu	Mecon	S.	
		Siam	Menan	S.	
		Cambodia	Ava	S.	

Some of theſe countries contain ſeveral others.

Aſiatic Turky contains

Countries	Georgia N.	Turcomania E. or Armenia	Curdiſtán E. or Aſſyria	Diarbec E
Ch. Cities	Teflis	Erzerum	Betlis	Mouſol
Countries	Eyraca S. E.	Arabia deſert S.	Natolia W.	Syria W
Ch. Cities	Bagdat		Smyrna	Aleppo

India weſt the Ganges contains

Northern Parts	Countries	Indoſtan N.	Cambaya S. W. or Guzarat	Bengala S. E.
	Ch. Cities	Delli	Surat	Patna
Malabar Coaſt	Countries	Decan or Viſapour	Biſnagar W. or Carnate	
	Ch. Cities	Goa	Calecut and Cochin	
Coromandel Coaſt	Countries	Biſnagar, or Carnate, E. ſide	K. Golconda	K. Orixa
	Ch. Cities	Madras	Golconda	Orixa

India eaſt the Ganges contains

Countries	K. Ava N.W.	K. Pegu W.	K. Siam Sd.	K. Malacca S.
Ch. Cities	Ava	Pegu	Siam	Malacca
Countries	K. Cambodia S.	K. Cochin China E.	K. Laos N.	K. Tonquin N. E.
Ch. Cities	Cambodia	Thoanoa	Lanchan	Keccio

591. *The principal Seas, Gulfs and Bays in Aſia, are*

Caſpian Sea, quite ſurrounded by Siberia on the north, Korazm eaſt, by Perſia on the ſouth, and by Georgia on the weſt.

Korean Sea, between Korea and the Iſlands of Japan.

Yellow Sea, between China and the Japan iſles.

Gulf of Cochin China, on the borders of Tonquin and Cochin China.

Bay of Siam, formed by the countries of Siam and Malacca.

Bay of Bengal, between India eaſt, and India weſt the Ganges.

Gulf of Perſia, having Perſia on the N. E. and Arabia on the S. W.

592. *The principal Iſlands belonging to Aſia, are*

Ladrone, or *Marian Iſles*, whoſe chief Iſland is Guam.

Japan Iſles	Ch. Iſles	Japan	Bongo	Tonſa
	Ch. Cities	Jeddo	Bongo	Tonſa
Philippines	Ch. Iſles	Luconia	Mindanao	Samar
	Ch. Cities	Manila	Mindanao	
Chineſe Iſles	Ch. Iſles	Formoſa	Ainan	Makao
	Ch. Cities	Taywanfu	Tan	Makau
Moluccos	Ch. Iſles	Celebes	Gilolo	Ceram
	Ch. Cities	Macaſſer	Gilolo	Ambay
Sunda Iſles	Ch. Iſles	Borneo	Sumatra	Java
	Ch. Cities	Banjar	Achin	Batavia

The *Andaman Iſles* to the weſt of Siam.
Nicobar Iſles weſt of Malacca.
Maldive Iſlands to the S. W. of Biſnagar.

The *Iſland of Ceylon* S. E. of Biſnagar; the chief city is Candy, or Candy Uta.

OF AFRICA.

593. This large continent is a peninſula joined to Aſia by the Iſthmus of Suez. On the N. E. it is ſeparated from Aſia by the Red ſea; it has the Indian ocean on the eaſt, the Southern on the ſouth, the Atlantic on the weſt, and the Mediterranean ſea on the north, which ſeparates it from Europe. It is ſituated between the latitudes of 37 degrees N. and 35 degrees S.; and between the longitudes of 18 degrees W. and 50 degrees E. from London; is about 4300 miles long, and 4200 miles broad.

594. The poſitions and names of the chief countries, cities, rivers and mountains, are contained in the following table.

Countries.	Poſition	Chief Cities.	Rivers.	Courſe.	Mountains
E. Morocco	N. W.	Fez	Mulvia	N.	Atlas
K. Algiers	N.	Algiers	Saffran	N.	Atlas
K. Tunis	N.	Tunis	Megarada	N.	Atlas
K. Tripoli	N.	Tripoli	Salines	N. E.	Atlas
K. Barca	N.	Docra			Meies
K. Egypt	N. E.	Cairo	Nile	N.	Gianadel
E. Abyſſinia or Ethiopia	E.	Ambamarjam	Nile	N.	
Ajan	E.	Adea	Madadoxa	S.	
Zanguebar	E.	Melinda	Cuama	E. S. E.	
Sofala	S. E.	Sofala	Amara	E.	Amara
Terra de Natal	S. E.	Natal	St. Eſprit	E.	Amara
Cafraria	S.	Cape Town	St. Chriſtopher	E.	Table
Mataman	S. S. W.		Angri	W.	Sunda
K. Benguela	S. S. W.	Benguela	Negros	W.	Sunda
K. Angola	S. W.	Loando	Coanza	W.	Sunda
K. Congo	S. W.	St. Salvador	Zaara	S. W.	Sunda
K. Loango	S. W.	Loango	Zette	S. W.	St. Eſprit
Biafara	S. W.	Biafara	Camerones	S. W.	St. Eſprit
K. Benin	S. W.	Benin	Formoſa	S. W.	
Guinea	S. W.	Cape Coaſt	Volta	S.	Sierra Leo
Mandinga	W.	James Fort	Gambia	W.	C. Verd
Sanhaga	W.	Sanhaga	Senagal	N. W.	
Biledulgerid	Mid. N.	Dara	Dara	S.	Atlas
Zara	Mid.	Zuenzega	Nubia	E.	
Nubia	Mid.	Nubia	Nubia	E.	
Negroland	Mid.	Tombute	Niger	W.	
Ethiopia inter.	Mid.	Chaxumo	Niger	W.	Luna
Monomugi	Mid. S.	Merango	Cuama	E. S. E.	Luna
E. Monomotapa	Mid. S.	Mogar	Amara	S. E.	Amara

Great part of the coaſts of Africa are ſubject to the European natio Thus the Kingdoms of Algiers, Tunis, Tripoli, Barca and Egypt, a either ſubject to the Ottoman or Turkiſh Empire, or acknowledge thei ſelves under its protection.

Abyſſi

Abyſſinia is governed by its own Emperor.

Ajan or Anian is peopled by a few wild Arabs.

In Zanguebar and Sofala, the Portugueſe have many black princes tributary to them.

Caffraria, or the country of the Hottentots, belongs to the Dutch.

The ſea coaſts of Guinea are uſually diſtinguiſhed by the names of the *Slave coaſt*, *Gold coaſt*, *Ivory coaſt*, *Grain coaſt*, and *Sierra Leone.*

The Engliſh, Dutch, French, Portugueſe and others, have ſeveral ſettlements along theſe coaſts, and even many miles up the country, particularly the Engliſh on the river Gambia, and the French on the river Senaga, or Senegal.

In the general table, the countries are taken in a very large ſenſe; for many of them contain a great number of ſtates independent one of the other, the particulars whereof are not known to Geographers.

595. *The principal Seas, Gulf and Bays in Africa, are*

The *Red Sea*, between Africa and Aſia: It waſhes the coaſt of Arabia on the Aſiatic ſide, and the coaſts of Egypt and Abyſſinia on the African ſide.

Moſambique Sea, between Africa and the iſland of Madagaſcar eaſtward.

Saldanna Bay in Caffraria, on the Ethiopic ocean.

Bight of Benin on the coaſt of Guinea, in the Ethiopic ocean.

596. *The principal African Iſlands are*

	Chief Iſle.	Chief Town.	Situation.
Madeira iſles	Maderia	Funchal	N. Atlantic ocean
Canary iſles	Canaria	Palma	N. Atlantic ocean
C. Verd iſles	St. Jago	St. Jago	N. Atlantic ocean
Ethiopian iſles	St. Helena		Ethiopic ocean
Komora iſles	Johanna	Demani	Indian ocean
Sokotora iſles	Zocotora	Calanſia	Indian ocean
Almirante iſles	But little	known.	Indian ocean

The iſland of *Madagaſcar*, one of the largeſt in the world, lies in the Indian ocean: It is divided into a multitude of little ſtates; ſome of them formed by the European privateers, and their ſucceſſors deſcended from mixing with the natives.

The iſlands of *Bourbon* and *Mauritius* lie in the Indian ocean, to the eaſt of Madagaſcar: Theſe belong to the French.

The Madeiras and Cape de Verd iſles belong to the Portugueſe.

The Canary iſles to Spain; St. Helena to England.

OF AMERICA.

597. This vaſt continent, called by ſome the new world, having been diſcovered by the Europeans ſince the year 1492, is uſually divided into two parts, one called North, and the other South America; being joined to one another by the Iſthmus of Darien.

North America lies between the latitudes of 10 degrees and 80 degrees north; and chiefly between the longitudes of 50 degrees and 130 degrees weſt of London; is about 4200 miles from north to ſouth, and about 4800 from eaſt to weſt. It is bounded on the eaſt by the north Atlantic ocean, by the Gulf of Mexico on the ſouth; on the weſt by the Pacific ocean, and by the Northern continent and ocean to the northward.

South America is bounded on the eaſt by the ſouth Atlantic ocean, by the Southern ocean to the ſouth, by the Pacific ocean on the weſt, and on the north by the Caribean ſea: It lies between the latitudes of 12 degrees north and 58 degrees ſouth; and between the longitudes of 45 degrees and 83 degrees weſt from London; is about 4200 miles long, and about 2200 miles in breadth.

598. The poſitions and names of the chief countries, cities, rivers and mountains, in north America, are in the following table.

Countries.	Poſition	Chief Cities.	Rivers.	Courſe.	Mountains.
California	W.	St. Juan			
New Mexico	S.	Santa Fe	N. River	S. S. E.	
Old Mexico	S. W.	Mexico	Panuco	E.	
Louiſiana	S.	Fort Louis	Miſſiſſipi	S.	
Florida	S.	St. Auguſtin	St. John	N. to E.	Apalachian
Georgia	S. S. E.	Savannah	Alatamaha	E. S. E.	Apalachian
Carolina	S. E.	Charles Town	Aſhly	S. E.	Apalachian
Virginia	E.	James Town	Powtomack	S. E.	Apalachian
Maryland	E.	Annapolis	Powtomack	S. E.	Apalachian
Penſilvania	E.	Philadelphia	Delawar	S.	Apalachian
Jerſeys	E.	New York	Albany	S.	
New England	E.	Boſton	Connecticut	S.	
Nova Scotia	N. E.	Hallifax	St. John	S. S. E.	Ladies
Canada	Mid.	Quebec	St. Lawrence	N. E.	
New Britain	N. N. E	Fort Rupert	Rupert	W.	
New Wales	N.	Port Nelſon	Nelſon	W.	

California, Old Mexico, New Mexico and Florida, belong to Spain

Louiſiana and Canada are poſſeſſed by the French.

All the other countries are in the hands of the Engliſh.

In ſouth America, the poſition and names of the chief countries, cities, rivers and mountains, are as follows.

Countries.	Poſition.	Chief Cities.	Rivers.	Courſe.	Mountains
Terra firma	N.	Panama	Oronoque	N. E.	
Peru	W.	Lima	Chuquimayo	W. N. W.	Andes
Chili	S. W.	St. Jago	Valpariſo	W.	Andes
Patagonia	S.		Deſaguadero	S.	Andes
La Plata	S. E.	Buenos Ayres	La Plata	S.	Andes
Paraguay	Mid.	Aſſumption	Paragua	S.	
Braſil	E.	St. Salvador	Rio Real	N. E.	
Amazonia	Mid.		Amazons	E.	
Guiana	N. E.	Surinam	Eſquebe	N. N. E.	

Terra firma, Peru, Chili, La Plata and Paraguay, are in the poſſeſſion of the Spaniards.

Braſil belongs to the Portugueſe.

Patagonia, Amazonia and Guiana, are poſſeſſed by the native Indians, except ſome parts of the coaſts of Guiana in the hands of the Dutch and French.

599. *The principal Seas, Gulfs and Bays, in America.*

The *Caribean Sea*, bounded by Terra firma on the ſouth, and a range of iſlands on the north and eaſt.

Gulf of Mexico, formed by Old Mexico, Louiſiana and Florida.

Bay of Campeachy, part of the Gulf of Mexico, on the Mexican coaſt.

Bay of Honduras, part of the Caribean ſea, next to Mexico.

Bay of Panama, in the Pacific ocean, next the Iſthmus of Darien.

Gulf of California, in the Pacific ocean, having California on the weſt.

Bay of Fundy, in Nova Scotia, north Atlantic ocean.

Gulf of St. Lawrence, in the north Atlantic ocean, bounded by Nova Scotia, New Britain, and ſome iſlands eaſtward and ſouth eaſtward.

Hudſon's Bay, between New Britain E. and New Wales W.

600. *The chief American Iſlands in the Atlantic ocean.*

Newfoundland, and *Cape Breton*, eaſt of the Gulf of St. Lawrence.

Bermudas, or *ſummer* iſlands, eaſt of Carolina.

Bahama iſles, ſouth eaſt of Florida.

Great Antilles	Cuba	Ch. town Havanna	lying E. of the Mexican gulf, and N. of the Carib. ſea.
	Hiſpaniola	Ch. town St. Domingo	
	Jamaica	Ch. town Kingſton	

Caribbe iſles, bounding the Caribean ſea on the E. and N. E.

Leſſer Antilles, on the N. N. E. of Terra firma, in the Caribbe ſea.

Terra del fuego, on the ſouth of Patagonia, in the ſouthern ocean.

Gallipago iſles, lying N. W. of Peru in the Pacific ocean.

Solomons iſles, ſouth of the Equator in the Pacific ocean.

SECTION IV.

Of Winds.

601. A Fluid is a body whoſe particles readily give way to any impreſſed force; and by this readineſs of yielding the particles are eaſily put into motion.

Thus, not only liquids, but ſteams or vapours, ſmoke or fumes, and others of a like kind, are reckoned as fluids.

From all parts of the earth vapours and fumes are conſtantly ariſing to ſome diſtance from its ſurface.

This is known by obſervation; and is chiefly cauſed by the heat o the ſun, and ſometimes from ſubterraneous fires ariſing from the accidental mixing of ſome bodies.

602. Air is a fine inviſible fluid ſurrounding the globe of the earth, and extended to ſome miles above its ſurface.

The Atmosphere is that collection of air, and the bodies contained in it, which circumſcribes the earth.

603. From a multitude of experiments air is found to be both heavy and ſpringy.

By its weight, it is capable of ſupporting other bodies, ſuch as vapours and fumes, in the ſame manner as wood is ſupported by water.

By its ſpringineſs or elaſticity, a quantity of air is capable of being expanded, or ſpreading itſelf ſo as to fill a larger ſpace *; and of being compreſſed, or confined in a ſmaller compaſs †.

604. Air is compreſſed or condenſed by cold, and expanded or rarifie by heat.

This is evident from a multitude of experiments.

An alteration being made by heat or cold in any part of the Atmoſphere, its neighbouring parts will be put into motion by the endeavou which the air always makes to reſtore itſelf to its former ſtate.

For experiments ſhew, that condenſed or rarified air will return t its natural ſtate, when the cauſe, whatever it be, of that condenſation o rarefaction is removed.

605. Wind is a ſtream or current of air which may be felt; and uſually blows from one part of the Horizon to its oppoſite part.

606. The *horizon*, beſides being divided into 360 degrees like all othe circles, is by mariners ſuppoſed to be divided into four *quadrants*, calle the north eaſt, north weſt, ſouth eaſt and ſouth weſt quarters; each o theſe quarters they divide into eight equal parts called points, and each point into four equal parts called quarter points.

So that the horizon is divided into 32 points, which are called *rhumb* or *winds*; to each wind is aſſigned a name, which ſhews from what poin of the horizon the wind blows.

The points of North, South, Eaſt and Weſt, are called *cardina points*; and are at the diſtance of 90 degrees, or 8 points from one another.

---

* Near 14000 times. *Wallis*'s Hydroſ. p. 13.

† Into $\frac{1}{60}$ part. Phil. Tranſ. N° 181.

607. Winds are either conſtant or variable, general or particular. *Conſtant winds* are ſuch as blow the ſame way, at leaſt, for ſeveral ours or days; and *variable winds* are ſuch as frequently ſhift within an our or day.

A *general wind* is that which blows the ſame way, over a large tract f the earth, almoſt the whole year.

A *particular wind* is what blows, in any place, ſometimes one way, nd ſometimes another indifferently.

If the wind blows gently it is called a breeze; if it blows harder it is alled a gale, or a ſtiff gale; and if it blows very hard it is called a torm *.

608. The following obſervations on the wind have been made by kilful ſeamen; and particularly by the great Dr. Halley.

1ſt. Between the limits of 60 degrees, namely, from 30° of north laitude to 30° of ſouth latitude, there is a conſtant eaſt wind throughout he year, blowing on the Atlantic and Pacific oceans; and this is called he *trade wind*.

FOR as the ſun, in moving from eaſt to weſt, heats the air more mmediately under him, and thereby expands it; the air to the eaſtvard is conſtantly ruſhing towards the weſt to reſtore the equilibrium, r natural ſtate of the Atmoſphere, and this occaſions a perpetual eaſt vind in thoſe limits.

2d. The trade winds near their northern limits blow between the north nd eaſt; and near the ſouthern limits they blow between the ſouth and aſt.

FOR as the air is expanded by the heat of the ſun near the Equator; herefore the air from the northward and ſouthward will both tend tovards the Equator to reſtore the equilibrium: Now theſe motions from he north and ſouth, joined with the foregoing eaſterly motion, will prouce the motions obſerved near the ſaid limits between the north and aſt, and between the ſouth and weſt.

3d. Theſe general motions of the wind are diſturbed on the continents nd near their coaſts.

FOR the nature of the ſoil may either cauſe the air to be heated or ooled; and hence will ariſe motions that may be contrary to the foreoing general ones.

4th. In ſome parts of the Indian ocean there are periodical winds which re called MONSOONS; that is, ſuch as blow half the year one way, nd the other half year the contrary way.

FOR air that is cool and denſe, will force the warm and rarified air in continual ſtream upwards, where it muſt ſpread itſelf to preſerve the quilibrium: So that the upper courſe or current of the air ſhall be contrary to the under current; for the upper air muſt move from thoſe arts where the greateſt heat is; and ſo by a kind of circulation, the N. E. trade wind below will be attended with a S. W. above; and a S. E. below with a N. W. above: And this is confirmed by the experience of ſeamen, who, as ſoon as they get out of the trade winds, immediately find a wind blowing from the oppoſite quarter.

---

* The ſwiftneſs of the wind in a great ſtorm is not more than 50 or 60 miles in an hour; and a common briſk gale is about 15 miles an hour.

5th. In the Atlantic ocean, near the coaſts of Africa, at about 10 leagues from ſhore, between the latitudes of 28° and 10° north, ſeame conſtantly meet with a freſh gale of wind blowing from the N. E.

6th. Thoſe bound to the Caribbe iſlands, acroſs the Atlantic ocean find, as they approach the American ſide, that the ſaid N. E. wind becomes eaſterly; or ſeldom blows more than a point from the eaſt, eithe to the northward or ſouthward.

Theſe trade winds, on the American ſide, are extended to 30, 31, o even to 32° of N. latitude; which is about 4° farther than what they extend to on the African ſide: Alſo to the ſouthward of the Equator, th trade winds extend 3 or 4 degrees farther towards the coaſt of Braſil o the American ſide, than they do near the Cape of Good Hope on th African ſide.

7th. Between the latitudes of 4° North and 4° South, the wind alway blows between the ſouth and eaſt: On the African ſide the winds ar neareſt the ſouth; and on the American ſide neareſt the eaſt. In theſ ſeas Dr. Halley obſerved, that when the wind was eaſtward, the weathe was gloomy, dark and rainy, with hard gales of wind: But when th wind veered to the ſouthward, the weather generally became ſerene with gentle breezes next to a calm.

Theſe winds are ſomewhat changed by the ſeaſons of the year; fo when the ſun is far northward, the Braſil S. E. wind gets to the ſouth and the N. E. wind to the eaſt; and when the ſun is far ſouth, the S. E wind gets to the eaſt, and the N. E. winds on this ſide of the Equato veer more to the north.

8th. Along the coaſt of Guinea, from Sierra Leone to the iſland o St. Thomas (under the Equator), which is above 500 leagues, the ſoutherly and ſouth weſt winds blow perpetually: For the S. E. trade win having paſſed the Equator, and approaching the Guinea coaſt within 8 or 100 leagues, inclines towards the ſhore, and becomes ſouth, the S. E. and by degrees as it comes near the land it veers about to ſouth S. S. W. and in with the land it is S. W. and ſometimes W. S. W This tract is troubled with frequent calms, violent ſudden guſts of win called Tornados, blowing from all points of the horizon.

The reaſon of the wind ſetting in weſt on the coaſt of Guinea, is in all probability owing to the nature of the coaſt, which being greatly heated by the ſun, rarifies the air exceedingly, and conſequently the coo air from off the ſea will keep ruſhing in to reſtore the equilibrium.

9th. Between the 4th and 10th degrees of north latitude, and between the longitudes of Cape Verd, and the eaſtermoſt of the Cape Verd iſles, there is a tract of ſea which ſeems to be condemned to perpetual calms, attended with terrible thunder and lightnings, and ſuch frequent rains, that this part of the ſea is called the *rains*. Ships in ſailing theſe 6 degrees have been ſometimes detained whole months, as it is reported.

The cauſe of this ſeems to be, that the weſterly winds ſetting in on this coaſt, and meeting the general eaſterly wind in this tract, balance each other, and ſo cauſe the calms; and the vapours carried thither by each wind meeting and condenſing, occaſion the almoſt conſtant rains.

The laſt three obſervations ſhew the reaſon of two things which Mariners experience in ſailing from Europe to India, and in the Guinea rade.

And firſt. The difficulty which ſhips in going to the ſouthward, ſpecially in the months of July and Auguſt, find in paſſing between he coaſt of Guinea and Braſil, notwithſtanding the width of this ſea is nore than 500 leagues: This happens becauſe the S. E. winds at that ime of the year commonly extend ſome degrees beyond the ordinary limits of 4° N. latitude; and beſides coming ſo much ſoutherly, as to be ometimes ſouth, ſometimes a point or two to the weſt; it then only remains to ply to windward: And if on the one ſide they ſteer W. S. W. hey get a wind more and more eaſterly; but then there is danger of alling in with the Braſilian coaſt or ſhoals; and if they ſteer E. S. E. hey fall into the neighbourhood of the coaſt of Guinea, from whence hey cannot depart without running eaſterly as far as the iſland of St. Thomas; and this is the conſtant practice of all the Guinea ſhips.

Secondly. All ſhips departing from Guinea for Europe, their direct ourſe is northward; but on this courſe they cannot go, becauſe the oaſt bending nearly eaſt and weſt, the land is to the northward: Therefore as the winds on this coaſt are generally between the S. and W. S. W. they are obliged to ſteer S. S. E. or ſouth, and with theſe ourſes they run off the ſhore; but in ſo doing they always find the winds more and more contrary: So that when near the ſhore they can e ſouth, at a greater diſtance they can make no better than S. E., and fterwards E. S. E.; with which courſes they commonly fetch the iſland f St. Thomas and Cape Lopez, where finding the winds to the eaſtward of the ſouth, they ſail weſterly with it till coming to the latitude f 4 degrees ſouth, where they find the S. E. wind blowing perpetually.

On account of theſe general winds, all thoſe that uſe the Weſt India ade, even thoſe bound to Virginia, reckon it their beſt courſe to get as oon as they can to the ſouthward, that ſo they may be certain of a air and freſh gale to run before it to the weſtward: And for the ſame eaſon thoſe homewards bound from America endeavour to gain the latitude of 30 degrees, where they firſt find the winds begin to be variable; tho' the moſt ordinary winds in the north Atlantic ocean come om between the ſouth and weſt.

10th. Between the ſouthern latitudes of 10 and 30 degrees in the Indian cean, the general trade wind about the S. E. by S. is found to blow all the ear long in the ſame manner as in the like latitudes in the Ethiopic cean: And during the ſix months from May to December, theſe winds each to within 2 degrees of the Equator; but during the other ſix onths from November to June, a N. W. wind blows in the tract lying etween the 3d and 10th degrees of ſouthern latitude, in the meridian f the north end of Madagaſcar; and between the 2d and 12th degree f ſouth latitude, near the longitude of Sumatra and Java.

11th. In the tract between Sumatra and the African coaſt, and from 3 degrees of ſouth latitude quite northward to the Aſiatic coaſts, including the Arabian ſea and the Gulf of Bengal, the Monſoons blow from September to April on the N. E.; and from March to October on the S. W. In the former half year the wind is more ſteady and gentle, and the weather clearer than in the latter ſix months: And the wind is more ſtrong and ſteady in the Arabian ſea than in the Gulf of Bengal.

12th. Between the iſland of Madagaſcar and the coaſt of Africa, and thence northward as far as the Equator, there is a tract, wherein from April to October there is a conſtant freſh S. S. W. wind; which to the northward changes into the W. S. W. wind, blowing at that time in the Arabian ſea.

13th. To the eaſtward of Sumatra and Malacca on the north of the Equator, and along the coaſts of Cambodia and China, quite thro' the Philippines as far as Japan, the Monſoons blow northerly and ſoutherly: the northern ſetting in about October or November, and the ſouthern about May: The winds are not quite ſo certain as thoſe in the Arabian ſeas.

14th. Between Sumatra and Java to the weſt, and New Guinea to the eaſt, the ſame northerly and ſoutherly winds are obſerved; but the firſt half year monſoon inclines to the N. W. and the latter to the S. E. Theſe winds begin a month or ſix weeks after thoſe in the Chineſe ſeas ſet in, and are quite as variable.

15th. Theſe contrary winds do not ſhift from one point to its oppoſite all at once; in ſome places the time of the change is attended with calms, in others by variable winds: And it often happens on the ſhores of Coromandel and China, towards the end of the monſoons, that there are moſt violent ſtorms, greatly reſembling the hurricanes in the Weſt Indies; wherein the wind is ſo vaſtly ſtrong, that hardly any thing can reſiſt its force.

All navigation in the Indian ocean muſt neceſſarily be regulated by theſe winds; for if Mariners ſhould delay their voyages till the contrary monſoon begins, they muſt either ſail back, or go into harbour and wait for the return of the trade wind.

SECTION V.

Of the Tides.

609. A TIDE is that motion of the water in the Seas and Rivers, by which they are found regularly to riſe and fall.

The general cauſes of the tides were diſcovered by Sir Iſaac Newton, and are deduced from the following conſiderations.

610. Daily experience ſhews, that all bodies thrown upwards from the earth, fall down to its ſurface in perpendicular lines; and as lines perpendicular to the ſurface of a ſphere tend towards the centre, therefore the lines, along which all heavy bodies fall, are directed towards the earth's centre.

As theſe bodies apparently fall by their weight or gravity; therefore the law by which they fall, is called the LAW OF GRAVITATION.

611. A piece of glaſs, amber, or ſealing wax, and ſome other things, being rubbed againſt the palm of a hand, or againſt a woollen cloth, unil it be warmed, will draw bits of paper, or other light ſubſtances towards it, when held ſufficiently near thoſe ſubſtances.

Alſo a Magnet or Loadſtone being held near the filings of iron or ſteel, or other ſmall pieces of theſe ſubſtances, will draw them to itſelf; and a piece of hammered iron or ſteel, that has been rubbed by a magnet, will have a like property of drawing iron or ſteel to itſelf.

And this property in ſome bodies of drawing others to themſelves in the foreſaid manner, is called ATTRACTION.

612. Now as bodies by their gravity fall towards the earth, it is not mproper to ſay it attracts thoſe bodies; and therefore in reſpect to the earth, the words gravitation and attraction may be uſed one for the other, as by them is meant no more than the power or law by which bodies tend towards its centre.

And it is likely that this is the cauſe why the parts of the earth adhere and keep cloſe to one another.

613. The incomparable Sir Iſaac Newton, by a ſagacity peculiar to himſelf, diſcovered from many obſervations, that this law of gravitation or attraction was univerſally diffuſed throughout the world; and that the regular motions obſerved among the heavenly bodies were governed by this ſame principle; ſo that the earth and moon attracted each other, and both of them were attracted by the ſun: Alſo that the force of attraction exerted by theſe bodies one on the other was leſs and leſs as the diſtance increaſed, in proportion to the ſquares of thoſe diſtances; that is, the power of attraction at double the diſtance was four times leſs, at triple the diſtance, nine times leſs, at quadruple the diſtance, ſixteen times leſs, and ſo on.

614. Now as the earth is attracted by the ſun and moon, therefore all the parts of the earth will not gravitate towards its centre in the ſame manner as if thoſe parts were not affected by ſuch attractions: And it is very evident that, was the earth intirely free from ſuch actions of the ſun and moon, the oceans being equally attracted towards its centre, on all ſides by the force of gravity, would continue in a perfect ſtagnation without ever Ebbing or Flowing: But ſince the caſe is

otherwiſe, the oceans muſt needs riſe higher in thoſe places where th ſun and moon diminiſh their gravity, or where the ſun and moon hav the greateſt attraction.

As the force of gravity muſt be diminiſhed moſt in thoſe parts o the earth to which the Moon is neareſt, or in the ZENITH; that is, where ſhe is vertical or perpendicularly over, and conſequently where her attraction is moſt powerful; therefore the waters in ſuch places will riſe higher, and it will be *full ſea* or *flood* in ſuch places.

615. *The parts of the earth directly under the moon, and alſo thoſe in their* NADIR, *viz. ſuch places diametrically oppoſite to thoſe where th moon is in the Zenith, will have the flood or high water at the ſam time.*

FOR either half the earth would gravitate equally towards the othe half, were they free from all external attraction.

But by the action of the moon, the gravitation of one half-earth towards its centre is diminiſhed, and of the other is increaſed.

Now in the half-earth next the moon, the parts in the zenith bein moſt attracted, and thereby their gravitation towards the earth's centr diminiſhed; therefore the waters in theſe parts muſt be higher than i any other part of this half-earth.

And in the half-earth fartheſt from the moon, the parts in the nadi being leſs attracted by the moon than the parts nearer to her, do therefore gravitate leſs towards the earth's centre, and conſequently the water in theſe parts muſt be higher than they are in any other part of thi half-earth.

616. *Thoſe parts of the earth where the moon appears in the horizon, o is 90 degrees diſtant from the Zenith and Nadir, will have the ebbs or lowe waters.*

FOR as the waters in the Zenith and Nadir riſe at the ſame time the waters in their neighbourhood will preſs towards thoſe places t maintain the equilibrium; and to ſupply the places of theſe, others wil move the ſame way, and ſo on to places 90° diſtant from the ſai Zenith and Nadir: Conſequently in thoſe places where the moo appears in the horizon, the waters will have more liberty to deſcen towards the centre; and therefore in thoſe places they will be th loweſt.

617. Hence it plainly follows, that the ocean, did it cover the ſurface of the earth, muſt put on a ſpheroidal, or egg-like figure; wherei the longeſt diameter paſſes thro' the place where the moon is vertical and the ſhorteſt diameter will be where ſhe is in the horizon. And a the moon apparently ſhifts her poſition from eaſt to weſt in going roun the earth every day, the longer diameter of the ſpheroid following he motion, will occaſion the two floods and ebbs obſervable in about ever 25 hours, which is the length of a lunar day; that is, the time ſpen between the moon's leaving the meridian of any place, and coming t it again: So that the time of high water any day is about an hour late than it was the preceding day. Thus ſuppoſe it is high water to day a 12 o'clock, it will be high water to-morrow about one in the afternoon.

618. *The time of high water is not preciſely at the time of the moon's ming to the meridian, but about three hours after.*

FOR the moon acts with ſome force after ſhe has paſt the meridian, ıd thereby adds to the libratory or waving motion which ſhe has put e water into, whilſt ſhe was in the meridian; in the ſame manner as ſmall force applied to a ball already raiſed to ſome height, will raiſe ſtill higher.

619. *The Tides are greater than ordinary twice every month; that is, out the times of new and full moon: Theſe are called* SPRING TIDES.

FOR at theſe times the actions of both the ſun and moon concur, or aw in the ſame right line; and therefore the ſea muſt be more elevat-: In *conjunction*, or when the ſun and moon are on the ſame ſide of e earth, they both conſpire to raiſe the water in the Zenith, and con-quently in the Nadir: And when the ſun and moon are in *oppoſition*, at is when the earth is between them, whilſt one makes high water in e Zenith and Nadir, the other does the ſame in the Nadir and Zenith.

620. *The tides are leſs than ordinary twice every month; that is about the nes of firſt and laſt quarters of the moon: And theſe are called* NEAP DES.

BECAUSE in the quarters of the moon, the ſun raiſes the water where e moon depreſſes it; and depreſſes where the moon raiſes the water; that the tides are made only by the difference of their actions.

It muſt be obſerved that the ſpring tides happen not directly on the w and full moons, but rather a day or two after, when the attractions the ſun and moon have conſpired together for a conſiderable time. In e manner the Neap tides happen a day or two after the quarters, when e moon's attraction has been leſſened by the ſun's for ſeveral days to-ther.

621. *When the moon is in her* PERIGÆUM, *or neareſt approach to the rth, the tides increaſe more than in the ſame circumſtances at other times.*

FOR according to the laws of gravitation, the moon muſt attract oſt when ſhe is neareſt to the earth.

622. *The ſpring tides are greateſt about the time of the* EQUINOXES, *at is about the middles of March and September, than at other times of e year; and the neap tides then are leſs.*

BECAUSE the longer diameter of the ſpheroid, or the two oppoſite ods, will at that time be in the earth's Equator; and conſequently will ſcribe a great circle of the earth; by whoſe diurnal rotation thoſe ods will move ſwifter, deſcribing a great circle in the ſame time they ed to deſcribe a leſſer circle parallel to the equator, and conſequently e waters being thrown more forcibly againſt the ſhores, they muſt riſe gher.

623. All the things hitherto explained would exactly obtain, was the hole ſurface of the earth covered with ſea: But ſince it is not ſo, and ere being a multitude of iſlands, beſide continents, lying in the way the tide, which interrupt its courſe; therefore in many places near the ores, there ariſe a great variety of other appearances beſide the fore-ping ones, which require particular ſolutions, wherein the ſituation of e ſhores, ſtraits, ſhoals and other things, muſt neceſſarily be conſi-red. For inſtance:

624. As the ſea * has no viſible paſſage between Europe and Afric let them be ſuppoſed one continent, extending from 72 degrees north 34 degrees ſouth, the middle between theſe two would be in latitu 19 degrees north, near Cape Blanco on the weſt coaſt of Africa: But is impoſſible that the flood tide ſhould ſet to the weſtward upon the we coaſt of Africa (for the general tide following the courſe of the moo muſt ſet from eaſt to weſt), becauſe the continent for above 50 degre both northward and ſouthward bounds that ſea on the eaſt; and therefo if any regular tide, as proceeding from the motion of the ſea, from ea to weſt, ſhould reach this place, it muſt either come from the nor of Europe ſouthward, or from the ſouth of Africa northward, to t ſaid latitude upon the weſt coaſt of Africa.

625. This opinion is further corroborated, or rather fully confirme by common experience, that the flood tide ſets to the ſouthward alo the weſt coaſt of *Norway*, from the north cape to the *Naze*, or entran of the *Baltic Sea*, and ſo proceeds to the ſouthward along the eaſt co of *Great Britain*, and in its paſſage ſupplies all thoſe ports with the ti one after another, the coaſt of Scotland having the tide firſt, becauſe proceeds from the northward to the ſouthward; and thus on the da of the full or change it is high water at *Aberdeen* at 12 h. 45 m. but *Tinmouth bar*, the ſame day, not till 3 h. From thence rolling to t ſouthward it makes high water at the *Spurn* a little after 5 h. but n till 6 h. at *Hull*, by reaſon of the time required for its paſſage up t river; from thence paſſing over the *Wellbank* into *Yarmouth road*, it mak high water there a little after 8 h. but in the *Pier* not till 9 h. and it r quires near an hour more to make high water at *Yarmouth* town; in t mean time ſetting away to the ſouthward, it makes high water at *Ha* *wich* at 10 h. 30 m. at the *Nore* at 12, at *Graveſend* 1 h. 30 m. and *London* at 3 h. all in the ſame day: And although this would ſeem contradict that hypotheſis, of the natural motion of the tide being fro eaſt to weſt, yet as no tide can flow weſt from the main continent *Norway* or *Holland*, or out of the *Baltic*, which is ſurrounded by t main continent except at its entrance, it is evident, that the tide we ha been now tracing by its ſeveral ſtages from *Scotland* to *London*, is ſu plied by the tide whoſe original motion is from eaſt to weſt; yet water always inclines to the level, it will in its paſſage fall towards a other point of the compaſs, to fill up vacancies where it finds them, a yet not contradict, but rather confirm the firſt hypotheſis.

626. While the tide or high water is thus gliding to the ſouthwa along the eaſt coaſt of *England*, it alſo ſets to the ſouthward along the w coaſts of *Scotland* and *Ireland*, a branch of it falls into St. George's cha nel, the flood running up north eaſt, as may be naturally inferred fr its being high water at *Waterford* above three hours before it is hi water at *Dublin* or thereabout on that coaſt; and it is three quarters an hour ebb at *Dublin* before it is high water at the *Iſle of Man*, &c.

But not to proceed further in particulars than our own or the *Brit* channel, we find the tides ſet to the ſouthward from the coaſt of *Irela* and in its paſſage a branch of it falls into the *Britiſh* channel betwe e *Lizard* and *Uſhant*; its progreſs to the ſouthward may be eaſily oved, by its being high water on the day of the full and change at *pe Clear* after 4 h. and at *Uſhant* about 6 h. and at the *Lizard* after h. The *Lizard* and *Uſhant* may properly be called the chaps of the *itiſh* channel, between which the flood ſets to the eaſtward along the aſts of *England* and *France*, till it comes to the *Goodwin* or *Galloper*, here it meets the tide beforementioned, which ſets to the ſouthward, ong the coaſt of England to the *Thames*, where theſe two tides meetig, contribute very much towards ſending a powerful tide up the *Thames* t *London*: And by the bye, when the natural courſe of the tide is intrupted by a ſudden ſhift of the wind; and between this northern and thern ſide, driving one back, and the other in, has been known to caſion twice high water in 3 or 4 hours, which by thoſe who did not nſider this natural cauſe was looked upon as a prodigy.

---

* *Varenius*'s Geogr. p. 813. Edit. 1734.

627. But now it may be objected, that this courſe of the flood tide, t, or eaſt north eaſt, up the channel, is quite contrary to the hypoſis of the general motion of the tides being from eaſt to weſt, and nſequently of its being high water where the moon is vertical, or any here elſe in the meridian.

In anſwer. This particular direction of any branch of the tide doth t at all contradict the general direction of the whole; a River, whoſe urſe is weſt, may ſupply canals which may wind north, ſouth, or even t, and yet the river keep its natural courſe; and if the river ebb and w, the canals ſupplied by it would do the ſame, but not keep exact e with the river, becauſe it would be flood, and the river advanced ſome height, before the flood reached the further part of the canals, d the more remote, the longer time it would require; and it may be led, that if it was high water in the river juſt when the moon was on meridian, ſhe would be far paſt it, before it could be high water in remoteſt part of thoſe canals or ditches, and the flood would ſet acding to the courſe of thoſe canals that received it, and could not ſet ſt up a canal of a different poſition; and as *St. George*'s channel, the *itiſh* channel, &c. are no more in proportion to the vaſt ocean, than ſe canals are to a large navigable river; it will evidently follow, that ong thoſe obſtructions and confinements, the flood may ſet upon any er point of the compaſs as well as weſt, and may make high water any other time as well as when the moon is upon the meridian, and no way contradict the general theory of the tide before aſſerted.

628. From the obſervations of many perſons, there have been collected the times when it is high water on the days of the new and full ons, on moſt of the ſea coaſts of Europe, and many other places: heſe times are uſually put in a table againſt the names of the places eſted in an alphabetical order; the like is followed in this work, only y are not given in a table by themſelves, but make a column in the le of the Latitudes and Longitudes of places; which column is not d up againſt many of the names in that table for want of a ſufficient lection of obſervations: This may be ſupplied by thoſe who have optunity and inclination.

The uſe of ſuch a Table is to find the time when it is high water at y of the places mentioned therein: But as this depends upon knowing the time when the moon comes to the meridian, and this on the moon age, and this on the knowledge how to find ſome of the common not in the Calendar; therefore it was thought convenient to introduce i this place a compendium of Chronology, wherein will be contained t ſeveral articles abovementioned.

SECTION VI.

Of Chronology.

629. CHRONOLOGY is the art of eſtimating, and comparing togethe the times when remarkable events have happened, ſuch as are related hiſtory.

An ÆRA or EPOCHA is a time when ſome memorable tranſaction o curred; and from whence ſome nations date, and meaſure their comp tations of time.

	Years of the World.	Years before Chriſt.
Some have dated their events from the creation of the world.	0000	4004
Others from the deluge or flood.	1656	2348
The Greeks from their Olympiads of 4 years each.	3228	1776
The Romans from the building of Rome.	3251	753
The Aſtronomers from Nabonaſſar king of Babylon.	3257	747
Some Hiſtorians from the death of Alexander the Great.	3676	324
The Chriſtians from the birth of Chriſt.	4004	A. D.
The Mahometans from the flight of Mahomet, and called the Hegira.	4626	622

In order to aſſign the diſtance between theſe, and other events, t Ancients found it neceſſary to have a large meaſure of time, the limits which was naturally pointed out to them by the return of the ſeaſo and this interval they called a year.

630. The moſt natural diviſion of the year appeared to them to be t returns of the new moon; and as they obſerved 12 new moons to happ within the time of the general return of the ſeaſons, they therefore f divided the year into 12 equal parts, which they called months: And they reckoned about 30 returns of morning and evening between times of the new moon and new moon, therefore they reckoned th month to conſiſt of 30 days, and their year or 12 months to contain 3 days; and this is what is generally underſtood by the Lunar year of Ancients.

631. But in length of time it was found that this year did not ag with the courſe of the ſun, the ſeaſons gradually falling later in the y than they had been formerly obſerved; this put them upon correct

e method of eſtimating their year, which they did from time to time,
taking a day or two from the month as often as they found it too
ng for the courſe of the moon ; and by adding a month, called an in-
rcalary month, as often as they found 12 Lunar months to be too ſhort
r the return of the four ſeaſons and fruits of the earth : This kind
year ſo corrected from time to time by the Prieſts, whoſe buſineſs it
as, is what is to be underſtood by the *Luni-ſolar* year ; which was an-
ently uſed in moſt Nations, and is ſtill among the *Arabs* and *Turks.*

As a great variety of methods were uſed in different countries to cor-
ct the length of the year, ſome by intercalating days in every year,
d others by inſerting months and days in certain returns or periods of
ars ; and theſe different methods being obſerved by ſome eminent men
create a conſiderable difference in the accounts of time kept by neigh-
uring Nations, thereby introducing a confuſion in the Chronological
der of times, they therefore invented certain periods of years called
cles, with which they compared the moſt memorable occurrences.

632. At length *Julius Cæſar* obſerving the confuſion which this va-
ty of accounts occaſioned ; and knowing that his order, as Emperor
the Romans, would be followed by a very conſiderable part of the
orld : He therefore, about 40 years before the birth of Chriſt, decreed
at every fourth year ſhould conſiſt of 366 days, and the other three
365 days each. This he did in conſequence of the information given
n by *Syſogenes* an eminent mathematician of Alexandria in Egypt; for
that time the philoſophers of the Alexandrinian ſchool knew, from
ength of experience, that the year conſiſted of about 365 days and a
arter; and this was the reaſon of ordering every fourth year to conſiſt
366 days, thereby compenſating for the quarter day omitted in each
the preceding three years: This method, called the *Julian Account*,
Old Stile, continued to be uſed in moſt Chriſtian ſtates until the
ar 1582.

The Aſtronomers ſince the time of *Julius Cæſar* have found that the
e length of the Solar year, or common year, is 365 days 5 hours 48
nutes 55 ſeconds &c. being leſs than the Julian of 365 days 6 hours,
about 11 minutes 5 ſeconds, which is about the 130th part of 86400,
ſeconds contained in a day ; ſo that in 130 Julian years there would
one day gained above 130 Solar years ; conſequently one day omitted
every 130 common years would bring the current account of time
agree very nearly with the motion of the ſun.

633. In the year of our Lord 325, when the *council of Nice* ſettled the
y for the celebration of Eaſter, the *Vernal Equinox* (that is the day in
ſpring when the ſun roſe at 6 and ſet at 6) happened on the 21ſt of
arch : But about the year 1580 the *Vernal Equinox* fell on the 11th of
arch, making a difference of about 10 days. Now *Gregory* the XIIIth,
o was Pope at that time, obſerving that this difference of time in
falling out of the *Equinox* would affect the intention of the *Nicene*
ncil concerning the time of the year appointed by them for the cele-
ation of Eaſter: He therefore in the year 1581 publiſhed a *Bull*, or-
ring that in the year 1582 the 5th of October ſhould be called the
th, and ſo on; whereby the 10 days taken off would cauſe the time
the *Vernal Equinox* to fall on the 21ſt of March, as at the time of

the *Nicene council.* And to prevent any future difference, all the ſucceeding hundredth years diviſible by 4, ſuch as the years 1600, 2000 2400, 2800, &c. ſhould contain 366 days; and the centuries or hundredth years not diviſible by 4, as 1700, 1800, 1900, 2100, &c. ſhoul contain only 365 days; the intermediate years to be reckoned as the uſed to be in the *Julian* or *Old Stile.* This Pope's alteration called th *Gregorian* or *New Stile*, was received in moſt of the Chriſtian ſtates. But ſome at that time choſe to continue the *Julian*; among whom, th Engliſh in the year 1752 reformed their account, and introduced amon themſelves a new one, that nearly correſponds with the *Gregorian.*

A certain length of the year being once ſettled, and a regular accoun of time in conſequence thereof being ſo fitted as to conform invariabl to the ſeaſons; it was natural for the States who received ſuch accoun to fit thereto a regiſter of the days in each month, and therein to no the days when any remarkable occurrence was to be commemorated and ſuch regiſter has obtained the name of *Calendar.*

634. The Calendar now in uſe among moſt of the Chriſtian ſtates con ſiſts of 12 months, called *January*, *February*, *March*, *April*, *May*, *Jun* *July*, *Auguſt*, *September*, *October*, *November*, *December*; theſe months a called *civil*; the number of days in each may be readily remember by the following rule.

635. Thirty days has *November*, *April*, *June* and *September*;
February has twenty eight alone, All the reſt have thirty one,

When the year conſiſts of 365 days: But in every fourth, which co ſiſts of 366 days, February has 29. This additional day was interc lated after the 24th of February, which in the old Roman Calenda was called the *ſixth of the calends of March*, and being this year reckon twice over, the year was called *Biſſextile* or LEAP YEAR.

Beſide the Months, time is alſo divided into Weeks, Days, Hour Minutes, &c. a year containing 52 weeks, a week 7 days, a day hours, an hour 60 minutes, &c.

In the Calendars it has been uſual to mark the ſeven days of the we with the ſeven firſt letters of the Alphabet; always calling the 1ſt January A, the 2d B, the 3d C, the 4th D, the 5th E, the 6th F, a the 7th G, and ſo on, throughout the year; and that letter anſwering all the ſundays for a year is called the DOMINICAL LETTER.

According to this diſpoſition, the letters anſwering to the firſt day every month in the year will be known by the following rule.

636. At Dover Dwells George Brown Eſquire,
Good Chriſtopher Finch And David Frier.

Where the firſt letter of each word anſwers to the letter belonging the firſt day of the Months in the order from January to December.

637. A year of 365 days contains 52 weeks and 1 day; and a Le year has 52 weeks and 2 days; therefore the firſt and laſt days of a co mon year fall on the ſame week day, ſuppoſe it *Monday*; then the n year begins on a *Tueſday*, the next year on *Wedneſday*, and ſo on to t eighth year, which would be on *Monday* again, did every year cont 365 days; alſo the Dominical letter would run backwards thro' all ſeven letters: But this round of ſeven years is interrupted by the Le years; for herein *February* having a 29th day annexed, the firſt Dor

ni

ical letter in *March* muſt fall a day ſooner than in the common year; o that Leap year has two Dominical letters, the one (ſuppoſing G) erving for *January* and *February*, and the other, which is the preceding etter (F) ſerves for the reſt of the Sundays in that year.

638. The SOLAR CYCLE, or cycle of the ſun, is a period of 28 ears, in which all the varieties of the Dominical letters will have hapened, and the ſame order of the letters will return as were 28 years beore. At the birth of Chriſt 9 years had paſt in this cycle.

For the changes, were all the years common ones, would be 7,
But the interruptions by leap year being every fourth year;
Therefore the changes will be 4 times 7, or 28 years.

This return of the Dominical letters is conſtant in the *Julian* acount: But in the *Gregorian*, where among the compleat centuries, or undredth years, only every fourth is leap year; the other three hunredth years, which according to the *Julian* would be leap years, are by e *Gregorians* only common years of 365 days: in theſe all the letters uſt be removed one place forwards in a direct order; and either year, ſtead of having two Dominical letters (as ſuppoſe D, C) will have only ne (as D), the dominical letters moving retrograde.

639. The LUNAR CYCLE, or the cycle of the moon, is a period of neteen years, containing all the variations of the days on which the w and full moons happen; after which they fall on the ſame days they d 19 years before: But when a centeſſimal or hundredth year falls in e cycle, the new and full moons, according to the New Stile, will l a day later than otherwiſe. The year of the birth of Chriſt was one ar after the beginning of this cycle.

This cycle, ſometimes called the *Metonic cycle*, from *Meton* an Athean who invented it about 432 years before Chriſt, is not ſo perfect s was at firſt imagined by thoſe who reckoned 19 ſolar years exactly qual to 235 lunations, or new moons; for by later obſervations the cle is found leſs than 19 years, by one hour twenty eight minutes; hereby the new moons will, in 311 years, happen a day earlier than cording to the Metonic account; and conſequently all thoſe feſtivals pending on the new moons, will in time be removed into different ſons of the year than at their firſt inſtitution.

640. The PRIME, or GOLDEN NUMBER, is the number of years pſed in this cycle. At the birth of Chriſt, the Golden number was 2.

641. The EPACT of any year, is the Moon's age at the beginning that year; that is, the days paſt ſince the laſt new moon.

The time between new moon and new moon is in the neareſt round mbers 29½ days; therefore the Lunar year conſiſting of 12 Lunations, uſt be equal to 354 days, which is 11 days leſs than the ſolar year of 35 days: Now ſuppoſing the Solar and Lunar years to begin togeter, the Epact is 0, the beginning of the next ſolar year, the Epact is 1; the 3d year the Epact is 22, the 4th 33, &c. But when the Epact ceeds 30, then an intercalary month of 30 days is added to the Lunar ar, making it conſiſt of 13 months; ſo that the Epact at the beginning the 4th year is only 3, the 5th 14, the 6th 25, the 7th 36, or only 6 on account of the intercalary month; and ſo on to the end of the cle of 19 years; at the expiration whereof, the ſame Epacts would run over again, was the cycle perfect; and the Epact would always b 11 times the prime.

642. By the Nicene council it was enacted,

1ſt. That Eaſter day ſhould be celebrated after the Vernal Equinox which at that time happened on the 21ſt of March.

2d. That it ſhould be kept after the 14th day of that moon whic happened neareſt to the 21ſt of March in common years, and neareſ the 20th of March in Leap years.

3d. That the Sunday next following the 14th day ſhould be Eaſte Sunday: which muſt always fall between the 20th or 21ſt of March and the 25th of April.

643. The Moon's southing at any place, is the time when ſh comes to the meridian of that place, which is every day later by abou 4/5 of an hour, or 48 minutes; occaſioned by the hours in a day being divided by the 30 times ſhe paſſes the meridian from new moon to nev moon.

The ſun and moon come to the Meridian at the ſame time on th day of new moon or change; alſo the moon comes to the oppoſite par of the ſame meridian, when in oppoſition, or at full moon: Hence between new and full, ſhe comes to the meridian in the afternoon; a full ſhe ſouths at midnight, and after full at paſt midnight, or in th morning; likewiſe when at change, ſhe riſes nearly with the ſun; a full ſhe riſes about the time the ſun ſets.

The motion of the tide is regulated by that of the moon, whoſ motion is 15 degrees an hour, or one point of the compaſs in 45 minutes.

644. The Roman indiction is a cycle of 15 years, uſed by the ancient Romans. Three years of this cycle was elapſed at the birth c Chriſt.

The Dionysian period is a cycle of 532 years, ariſing by multiplying together 28 and 19, the ſolar and lunar cycles, and was contrive by *Dionyſius Exiguus*, a Roman abbot, about the year of Chriſt 527, a period for comparing of chronological events.

The Julian period contains 7980 years; it ariſes by multiplyin together 28, 19, 15, the cycles of the Sun, Moon and Indiction. Thi was alſo contrived as a period for chronological matters; and its beginning is put 710 years before the uſual date of the creation.

From the principles laid down in the preceding articles, depend th ſolution of the following Problems.

645. Problem I. *To find whether any given year be Leap year.*

Rule. Divide the given year by 4, if 0 remains it is leap year; 1, 2, or 3 remains, it is ſo many years after.

Obſerving that the years 1800, 1900, 2100 &c. are common years.

Ex. I. *Is* 1752 *Leap year?*
4)1752(438
Remains 0, ſo it is leap year.

Ex. II. *Is* 1759 *Leap year?*
4)1759(439
Remains 3 years paſt leap year.

64

646. **Problem II.** *To find the Dominical letter till the year* 1800.

Rule. To the given year add its fourth part, divide the ſum by 7; the remainder taken from 7 leaves the index of the letter in common years; reckoning A 1, B 2, C 3, *&c.*

But in Leap years, this letter and its preceding one are the domi-ical letters.

Ex. I. *For the year* 1753.
4)1753
438
7)2191(313
Remains 0. Then 7 — 0 = 7 = G.
So G is the Dom. letter.

Ex. II. *For the year* 1756.
4)1756
439
7)2195(313
Remains 4. Then 7 — 4 = 3 = C.
So D, C, are the Dom. letters.

647. **Problem III.** *To know on what week day any propoſed day will ıll.*

Rule. Find the dominical letter (646); Alſo the week day the 1ſt f the propoſed month falls on (636); And hence the name of the ropoſed day of the month will be known, obſerving that the 1ſt, 8th, 5th, 22d and 29th days of any month fall on the ſame week day.

Ex. I. *In* 1753 *on what day of he week does the* 12*th of April fall?*

he dominical letter is G,
nd the 1ſt of April is G,
herefore April 8th is Sunday,
onſequently the 12th is Thurſday.

Ex. II. *On what day of the week does* 24*th of September fall in* 1756?

The dominical letter is C,
And the 1ſt of Sept. is F or Wedneſd.
Therefore the 22d is Wedneſday,
Conſequently the 24th is Friday.

648. **Problem IV.** *To find the year of the Solar, Lunar and Indicti-n cycles.*

Rule. To the given year add 9 for the Solar, 1 for the Lunar, 3 for the Indiction: Divide the ſums in order by 28, 19, 15; the remainder in each ſhews the year of its reſpective cycle. (638, 639, 644)

Exam. *Required the years of the Solar, Lunar and Indiction cycles for he year* 1753?

1753
+ 9
28)1762(62
Rem. 26 = Solar cycle.

1753
+ 1
19)1754(92
6 = Lunar cycle, or Gold. N°.

1753
+ 3
15)1756(117
1 = Indiction cycle.

Whereby it appears, that the year 1753 is the
26th year of the 63d Solar cycle
6th year of the 93d Lunar cycle
1ſt year of the 118th Indiction cycle.
ſince the birth of Chriſt.

649. PROBLEM V. *To find the Epact till the year* 1900.

RULE. Multiply the golden number for the given year by 11, and divide the product by 30; from the remainder take 11, leaves the Epact.

If the remainder is leſs than 11, add 19 to it, and it gives the Epact.

Ex. I. *Find the Epact for* 1753?
The Golden N°. is 6 (648)
Multiply by 11
30)66(2
Remains 6, leſs than 11.
Add 19
The ſum 25 = Epact.

Ex. II. *Find the Epact for* 1760?
The Golden N°. is 13, found by 648.
Multiply by 11
30)143(4
Remains 23, more than 11.
Subtract 11
Leaves 12 = Epact.

650. PROBLEM VI. *To find the Moon's age.*

RULE. To the Epact add the number, and day of the month; their ſum, if under 30, is the Moon's age.

But if that ſum is greater, 30 taken from it leaves the Moon's age.

The Moon's age taken from 30 leaves the day of the next change.

When the ſolar and lunar years begin together, the moon's age on the 1ſt of each month, or the monthly Epacts, are called the numbers of the month,

and are

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
0	2	1	2	3	4	5	6	8	8	10	10

Ex. I. *What is the Moon's age on the 21ſt of March* 1753?
The Epact is 25 (649)
The N° of month 1
The day of month 21
The ſum is 47
Take away 30
Leaves 17 = Moon's age.
Then (30 — 17 =) 13 days after the 21ſt of March, or Apr. 3d is new moon.

Ex. II. *What is the Moon's age on the 20th of March* 1760?
The Epact is 12. (649)
Then 12 + 1 + 20 = 33 is the ſum of the Epact, number and day of the month.
And (33 — 30 =) 3 = the Moon's age.
Alſo (30 — 3 =) 27 days after the 20th of March, or April the 16th is the day of the next new moon.

651. PROBLEM VII. *To find when Eaſter day will happen.*

RULE. Find the Moon's age on March 21ſt in common years, or on March 20th in leap years; and if it be 14, find the week day, and the Sunday following is Eaſter day.

If the Moon's age is not 14, reckon as many days forward as make 14; find the corresponding week day, and the next Sunday following is Eaſter day.

Ex. I. *On what day does Eaſter unday fall in the year* 1753?
or 1753 the dom. letter is G. (646)
n Mar. 21 the Moon's age is 17 (650)
he next new moon is on Apr. 3d.
nd 14th day is on April 16.
pril the 1ſt is G, or Sunday. (647)
pril the 16th is Monday.
hen Eaſter Sunday is Apr. 22d.

Ex. II. *Required the time of Eaſter day in the year* 1760?
For 1760 the dom. letter is E. (646)
On Mar. 20 the Moon's age is 3. (650)
So that the neareſt new moon to Mar. 20th falls on the 18th, and the 14th day of that Moon is Mar. 31.
Mar. 1ſt is D, or Saturday. (647)
Then the 31ſt is Monday.
And the next Sunday or Eaſter day is on April the 6th.

652. PROBLEM VIII. *To find the time of the Moon's ſouthing.*

RULE. Multiply the Moon's age by 4, the product divided by 5, quotes the hours, and the remainder multiplied by 12 gives the additional minutes.

If this time is leſs than 12 hours, it is the time of the ſouthing after idday: But if greater, 12 hours taken from it, leaves the ſouthing ter midnight.

Ex. I. *At what time does the moon me to the meridian, Mar.* 21, 1753?
he Moon's age is 17 days (650)
4
5)68(13 h. 36 m.
Remains 3
12
36 min.
nſwer, at 1 h. 36 m. in the morning.

Ex. II. *Required the time of the moon's ſouthing on the* 20*th of March*, 1760?
The Moon's age is 3 days (650)
4
5)12(2 h. 24 m.
Remains 2
12
24 min.
Anſwer, at 2 h. 24 m. in the afternoon.

653. PROBLEM IX. *To find the time of high water at any place.*

RULE. To the time of the moon's ſouthing, add the time the moon has paſſed the meridian to make high water at that place; and the ſum ſhews the time of high water.

The diſtance of the moon from the meridian when high water, is ound in the right hand column of the Table, art. 659, againſt the ame of the place.

Ex. I. *On the* 21*ſt of March*, 1753, *what time is it high water at ondon?*
he moon ſouths at 1 h. 36 m. A.M.* (652)
t Lond. ☽ bears I. E. or S. W. } 3 00
he ſum gives the me of high water } 4 36 A. M.

Ex. II. *Required the time when it is high water at Uſhant March* 20, 1760?
The moon ſouths at 2 h. 24 m. P. M. † (652)
At Uſhant ☽ bears N. E. by E. and S.W. by W. or is } 3 45 paſt the Mer.
H. water at Uſhant 6 09 P. M.

---

* A. M. ſignifies before noon, or morning.

† P. M. ſignifies after noon, or evening.

SECTION VII.

Geographical Problems.

654. **Problem I.** *Given the latitudes of two places, Required their difference of latitude.*

Case I. When the latitudes of the given places have the ſame name.

Rule. Subtract the leſſer latitude from the greater, the remainder is the difference of latitude.

Exam. I. *What is the difference of latitude between London and Rome?*

London's lat.	51° 32′ N.
Rome's lat.	41 54 N.
Diff. lat.	9 38
	60
	578 miles.

Exam. II. *What is the difference of latitude between the Lizard and the Iſland of Madeira?*

Lizard's lat.	49° 57′ N.
Madeira's lat.	32 38 N.
Diff. lat.	17 19
	60
	1039 miles.

Exam. III. *What is the difference of latitude between the Iſland of St. Helena and the Cape of Good Hope?*

C. Good Hope's lat.	34° 15′ S.
St. Helena's lat.	16 00 S.
Diff. lat.	18 15
	60
	1095 miles.

Exam. IV. *A ſhip from the latitude of 43° 18′ N. is come to the lat. of 34° 49′ N. Required the diff. of latitude?*

Lat. from	43° 18′ N.
Lat. in	34 49 N.
Diff. lat.	8 29
	60
	509 miles.

Case II. When the latitudes of the given places have contrary names.

Rule. Add the latitudes together, and the ſum will be the difference of latitude.

Exam. I. *Required the diff. of lat. between C. Finiſterre and C. St. Roque?*

C. Finiſterre lat.	43° 15′ N.
C. St. Roque lat.	5 00 S.
Diff. lat.	48 15
	60
	2895 miles.

Exam. II. *What is the difference of latitude between the Iſland of Barbados and C. Negro?*

I. of Barbados's lat.	13° 00′ N.
C. Negro's lat.	16 30 S.
Diff. lat.	29 30
	60
	1770 miles.

Exam. III. *Required the difference of latitude between C. Horn and C. Corientes in Mexico?*

Cape Horn's lat.	55° 42′ S.
C. Corientes's lat.	20 18 N.
Diff. lat.	76 00
	60
	4560 miles.

Exam. IV. *A ſhip from the lat. o 8° 28′ S. has ſailed north to the lat. 6 45′ N. Required the diff. of latitude*

Lat. from	8° 28′ S.
Lat. in	6 45 N.
Diff. lat.	15 13
	60
	913 miles.

655. **Problem II.** *Given the latitude of one place, and the difference of latitude between it and another place: Required the latitude of the other.*

Case I. When the given latitude d difference of latitude have the ſne name.

Rule. To the given latitude, add e degrees and minutes in the diff. latitude, that ſum is the other itude, of the ſame name.

Exam. I. *A ſhip from the lati-tle of* 38° 14′ *N. ſails north till difference of latitude is* 12° 32′: *hat latitude is ſhe come to?*

Lat. from	38° 14′ N.
Diff. lat.	12 32 N.
Lat. in	50 46 N.

Exam. II. *A ſhip from the Iſland Aſcenſion runs ſouth till her diff. latitude is* 5° 37′: *What is the ſent latitude of the ſhip?*

I. Aſcenſion's lat.	7° 41′ S.
Diff. lat.	5 37 S.
hip's lat.	13 18 S.

Exam. III. *A ſhip from the Iſland Madeira ſails N.* 675 *miles: What itude is ſhe in?*

Madeira's lat.	32° 38′ N.
Diff. lat. $\frac{675}{60}$ (22) =	11 15 N.
hip's lat.	43 53 N.

xam. IV. *Three days ago we were the latitude of the Cape of Good pe, and have run each day* 92 *miles ectly S. What is our preſent lati-te?*

Good Hope's lat.	34° 15′ S.
Diff. lat. $\frac{92 \times 3}{60}$ (22) =	4 36 S.
reſent latitude	38 51 S.

Case II. When the given latitude and difference of latitude have contrary names.

Rule. Take the difference between the given latitude and the degrees and minutes in the diff. of latitude, the remainder is the other latitude, of the ſame name with the greater.

Exam. I. *A ſhip from the latitude of* 38° 14′ *N. ſails ſouth till her difference of latitude is* 12° 32′: *What latitude is ſhe come to?*

Lat. from	38° 14′ N.
Diff. lat.	12 32 S.
Lat. in	25 42 N.

Exam. II. *A ſhip from the Iſland of Aſcenſion runs north till her diff. lat. is* 5° 37′: *What is the preſent latitude of the ſhip?*

I. Aſcenſion's lat.	7° 41′ S.
Diff. lat.	5 37 N.
Ship's lat.	2 04 S.

Exam. III. *A ſhip from Sierra Leona ſails S.* 839 *miles: What latitude is ſhe in?*

Sierra Leona's lat.	8° 30′ N.
Diff. lat. $\frac{839}{60}$ (22) =	13 59 S.
Ship's lat.	5 29 S.

Exam. IV. *Four days ago we were in the latitude of the Iſland of St. Mathew, and ſailed due north* 6 *miles an hour: What latitude is the ſhip in?*

St. Mathew's lat.	1° 23′ S.
Diff. lat. $\frac{6 \times 24 \times 4}{60}$ (22) =	9 36 N.
Ship's latitude	8 13 N.

656. **Problem III.** *Given the longitudes of two places, Required the difference of longitude.*

Rule. If the longitudes are of the ſame name, their difference is difference of longitude required.

But if the longitudes are of different names, their ſum gives the ference of longitude.

And if this ſum exceeds 180 degrees, take it from 360 degrees, there remains the difference of longitude.

Exam. I. *Required the difference of longitude between London and Naples?*

London's long.	00° 00′ E.
Naples's long.	14 45 E.
Diff. longitude	14 45
	60
	885 miles.

Exam. II. *A ſhip in longitude 14° 45′ W. is bound to a port in longitude 48° 18′ weſt: What diff. of longitude muſt ſhe make?*

Ship's long.	14° 45′ W.
Long. bound to	48 18 W.
Diff. longitude	33 33
	60
	2013 minutes.

Exam. III. *What is the difference of longitude between Cape Gardafuir and Cape Comorin?*

C. Gardafuir's long.	50° 25′ E.
C. Comorin's long.	78 17 E.
Diff. longitude	27 52
	60
	1672 minutes.

Exam. IV. *Required the diff. longitude between St. Chriſtophe and Cape Negro?*

St. Chriſtopher's long.	62° 50′ W
C. Negro's long.	11 30 E.
Diff. longitude	74 20
	60
	4460 minut

Exam. V. *A ſhip in longit 140° 20′ W. is bound to a place longitude 139° 35′ E. What diff. longitude muſt ſhe make?*

Ship's long.	140° 20′ W
Long. bound to	139 35 E,
	279 55
	360 00
Diff. long.	80 05

Exam. VI. *What is the differe of longitude between Cape Horn the Straits of Manila?*

C. Horn's long.	66° 00′ W.
Str. Manila's long.	124 00 E.
	190 00
	360 00
Diff. longitude	170 00

657. Sometimes the diff. long. between two places is eſtimated by diff. of time, allowing an hour to every 15 degrees of longitude, and min. of time for every 15 min. of a deg. or a deg. for every 4 min. of ti

Exam. *Having at 6 h. 48 m. P. M. obſerved at ſea a certain appeara in the heavens, which I know was ſeen the ſame inſtant at 3 h. 25 m. P. in London: Required the diff. longitude between the places of obſervation.*

From	6 h. 48 m.	3 h. =	45 deg.
Take	3 35	13 m. =	3 15′
Leaves	3 13 = diff. time.	Sum	48 15 = diff. longitu

And becauſe the hour of appearance at London was leaſt, therefore I kn myſelf to be to the eaſtward of London.

6

658. **Problem IV.** *Given the longitude of one place, and the difference of longitude between that and another: Required the longitude of the ſecond place.*

Rule. If the given longitude and difference of longitude are of a contrary name, their difference is the longitude required; and is of the ſame name with the greater.

But if the given longitude and difference of longitude are of the ſame name, the ſum is the longitude ſought, of the ſame name with the given place.

And if the ſum is greater than 180 degrees, take it from 360 degrees, remains the longitude required, of a contrary name with that of the given place.

Exam. I. *A ſhip from the lon- tude of* 41° 12′ *E. ſails weſtward til her difference of longitude is* ; 47′ *: What is her preſent longi- de?*

Ship's longitude	41° 12′ E.
Diff. long.	15 47 W.
Preſent long.	25 25 E.

Exam. II. *A ſhip from Cape harles in Virginia ſails eaſtward til ſhe has altered her longitude* 22° 3′ *: What longitude is ſhe in?*

C. Charles's long.	76° 07′ W.
Diff. long.	22 53 E.
Ship's long.	53 14 W.

Exam. III. *Four days ago I de- rted from C. St. Sebaſtian in Mada- ſcar, and I have made each day 5 miles of E. longitude: Required e longitude the ſhip is in?*

75		
4	C. Sebaſ. long.	49° 13′ E.
	Diff. long.	5 00 E.
o)30,0		
	Ship's long.	54 13 E.
5 0		

Exam. IV. *A ſhip from Cape Finiſterre ſails weſtward, and finds ſhe has altered her longitude* 587 *miles: What longitude is ſhe arrived in?*

C. Finiſterre's long.	9° 20′ W.
Diff. long. $\frac{587}{60}$	9 47 W.
Long. in	19 07 W.

Exam. V. *A ſhip from Cape St. Lucar in California has made* 87° 18′ *of weſt longitude: What longitude is ſhe in?*

C. Lucar's long.	111° 35′ W.
Diff. long.	87 18 W.
	198 53 W.
	360 00
Ship's longitude	161 07 E.

Exam. VI. *Seven days ago my longitude was* 172° 17′ *W. and I have made each day* 132 *miles of weſt longitude: Required my preſent longitude?*

132	Departed long.	172° 17′ W.
7	Diff. long.	15 24 W.
6,0)92,4		187 41
		360 00
15 24	Preſent long.	172 19 E.

659. A TABLE

Containing the Latitudes and Longitudes of the chief towns, iſland bays, capes and other parts of the ſea coaſts in the known world; co lected from the moſt authentic obſervations and charts extant; with t times of high water on the days of the new and full moon.

The longitudes are reckoned from the meridian of London. B the Latitude and Longitude of an iſland or harbour is meant the midd of that place.

Note, B. ſtands for bay; C. for cape; R. for river; Po. for port; P for point; I. for iſle; St. for ſaint; G. for gulf; M. for moun Eu. for Europe; Aſ. for Aſia; Af. for Africa; Am. for America; Atl. for Atlantic; Ind. for Indian; Med. ſea, for Medi terranean ſea; Wh. ſea, for White ſea; Archip. for Arch pelago; Nov. Sco. for Nova Scotia; Phil. I. for Philippin Iſles; Adriat. for Adriatic; Eng. for England: Beſide oth contractions which will be eaſily underſtood.

Names of places.	Con	Country	Coaſt.	Latitude.	Longitud.	H. Wate
A				° ′	° ′	
I. Abacco or Lucayos N. pt.	Am.	Bahama I.	Atl. Ocean	27 12N.	77 05W	
S. pt				26 15N.	77 01W	
Abbrevrak	Eu.	France	Eng. Chan.	48 32N.	4 15W	4h. 30
St. Abbſhead	Eu	Scotland	Germ. Ocean	55 55N.	1 56W	
I. Abdeleur	Af.	Anian	Indian Sea	11 55N.	51 45E.	
Aberdeen	Eu.	Scotland	Germ. Ocean	57 06N.	01 44W	0 45
Abo	Eu.	Finland	Bal. Sea	60 30N.	21 30E.	
Abrolhos bank	Am.	Braſil	Atl. Ocean	18 22 S.	38 45W	
Abrollo bank N. pt	Am.	Bahama	Atl. Ocean	21 33N.	69 50W	
Acapulco. See Aquapulco.						
Achen	Aſ.	I. Sumatra	Ind. Ocean	5 15N.	95 55E.	
Aden	Aſ.	Arabia	Indian Sea	12 55N.	45 35E.	
I. Admiralties	Eu.	Nov. Zem	N. Ocean	75 05N.	52 50E	
I. Agalega or Gallega	Af.	Madagaſ.	Ind. Ocean	10 15 S.	54 46E.	
C. St. Agnes	Am.	Patagon	S. Atl. Ocean	53 55 S.	62 47W	
Agra	Aſ.	India	Moguls	26 43N.	76 49E.	
I. St. Aguſta	Eu.	Dalmatia	Adriat. Sea	42 40N.	18 57E	
C. Ajuga	Am	Peru	S. Ocean	6 38 S.	80 50W	
B. Alagoa	Af.	Caffers	S. Ocean	25 30 S.	33 33E.	
Iſ. Aland	Eu.	Sweden	Balt. Sea	60 20N.	21 30E.	
R. Albany	Am.	New S Wales	Hud. Str.	52 35N.	85 18W	
I. Alboran	Af.	Algier	Medit. Sea	36 00N.	2 27W	
Aldborough	Eu.	England	Germ. Ocean	52 20N.	1 25E	9 45
I. Alderney	Eu.	England	Eng. Chan.	49 48N.	2 11W	12 00
Aleppo	Aſ.	Syria	Medit. Sea	35 45N.	36 25E	
Alexandretta	Aſ.	Syria	Medit. Sea	36 35N.	36 25E	
Alexandria	Af.	Egypt	Medit. Sea	31 11N.	30 21E	
I. Algeranca	Af.	Canaries	Atl. Ocean	29 45N.	12 13W	
Algier	Af.	Algier	Medit. Sea	36 49N.	2 18E	
Alicant	Eu	Spain	Medit. Sea	38 34N.	0 07W	
I. Alicur, Lipari Iſ.	Eu.	Italy	Medit. Sea	38 31N.	14 37E.	

Names of Places.	Con.	Countries.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
Alkoſir	Af.	Egypt	Red Sea	26 20N.	34 41 E.	
. All Saints, or Todos, Sanctos	Am.	Braſil	Atl. Ocean	13 05 S.	38 45W	
Almeria	Eu.	Spain	Medit. Sea	36 51N.	2 15W	
s. Almirante, limits	Af.	Zanguebar	Ind. Ocean	5 45 S. 4 30 S.	52 30 E. 55 40 E.	
Altur	Af.	Arabia	Red Sea	28 20N.	34 19 E.	
. Amazons, mouths	Am.	Terra Fir.	Atl. Ocean	0 30 S.	47 35W 49 20W	6h. 00m.
. Amboyna	Af.	Moluc. I.	Ind. Ocean	4 25N.	127 25 E.	
s. Ambroſa	Am.	Chili	S. Ocean	25 30 S.	83 20W	
. Ameyland	Eu.	Dutchlnd.	Germ. Oce.	53 30N.	6 20 E.	7 30
. Amoy	Af.	China	S. Ocean	24 30N.	118 45 E	
mſterdam	Eu.	Dutchlnd.	Germ. Oce.	52 23N.	05 04 E.	3 00
. Amſterdam	Af.	S. Contin.	Ind. Ocean	37 55 S.	75 15 E.	
. Amſterdam	Af.	S. Contin.	S. Ocean	21 25 S.	179 41W	
. Anabona	Af.	Eth. coaſt	Atl. Ocean	2 36 S.	5 35 E.	
ncona	Eu.	Italy	Mediterran.	43 54N.	14 20 E.	
s. Andaman, limits	Af.	India	B. Bengal	14 00N. 10 08N.	93 05 E. 93 35 E.	
. Andaro	Af.	India	Ind. Ocean	10 00N.	73 40 E.	
. St. Andero Sotovento	Am.	Mexico	Atl. Ocean	12 30N.	81 35W	
. St. Andrea	Af.	Madagaſ.	Ind. Ocean	15 46 S.	45 22 E.	
t. Andrews	Eu.	Scotland	Germ. Oce.	56 18N.	2 37W	2 15
. An- N. pt. droſs S. pt.	Am.	Bahama I.	Atl. Ocean	25 00N. 23 30N.	77 58W 77 00W	
. Angaſay	Af.	Madagaſ.	Ind. Ocean	17 00 S.	58 40 E.	
. St. Angelo	Eu.	Turkey	Archipelago	36 27N.	33 38 E.	
ount St. Angelo	Eu.	Italy	Med. Sea	41 42N.	16 16 E.	
. d'Angra	Af.	Ethiopia	N. Atl. Oce.	01 00N.	9 35 E.	
. d'Anguilhas	Af.	Caffers	Ind. Ocean	34 45 S.	21 40 E.	
Anguilla	Am.	Antil. Is.	Atl. Ocean	18 15N.	62 57W	
Anholt	Eu.	Denmark	Sound	56 40N.	12 00W	0 00
. Ann	Am.	New Eng.	W. Ocean	42 50N.	70 27W	
. Queen Ann	Am.	Groenlnd.	N. Ocean	64 15N.	50 30W	
. Ann's Foreland	Am.	N. Main	Hudſon'sStr.	64 08N.	74 36W	
nnapolis Royal	Am.	N. Scotia	B. Fundy	45 00N.	64 00W	
Antego	Am.	Caribbe I.	Atl. Ocean	16 57N.	61 50W	
ntibes	Eu.	France	Medit. Sea	43 34N.	07 13 E.	
Ante- W. pt. coſt E. pt.	Am.	Canada	B. St. Laurence	50 00N. 49 33N.	62 08W 59 35W	
ntiochetta	Af.	Syria	Medit. Sea	36 08N.	36 17 E.	
. d'Antifer	Eu.	France	Eng. Chan.	49 47N.	0 34 E.	
. Antonio	Am.	I. Cuba	Atl. Ocean	21 45N.	84 05W	
St. Antonio	Af.	CapeVerd	Atl. Ocean	17 45N.	24 23W	
. St. Antony	Am.	Magellan	S. Atl. Oce.	36 45 S.	53 42W	
ntwerp	Eu.	Flanders	R. Scheld	51 13N.	4 29 E.	6 00
. Apalaxy	Am.	Florida	G. Mexico	30 00N.	83 53W	
Apalioria	Af.	India	Ind. Ocean	9 08 S.	79 40 E.	

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water
				° ′	° ′	
Aquapulco	Am.	Mexico	S. Sea	17 10N.	101 40W	
Aquatulco	Am.	Mexico	S. Sea	15 27N.	96 03W	
Archangel	Eu.	Ruſſia	White Sea	64 30N.	41 30 E.	6h. 00m
I. d'Areas	Am.	Mexico	G. Mexico	20 45N.	92 35W	
Arica	Am.	Peru	S. Sea	18 27 S.	71 05W	
I. Arran	Eu.	Ireland	St. Geo. Ch.	54 48N.	8 59W	
I. Aſcending	Am.	Braſil	S. Atl. Oce.	20 42 S.	28 30W	
I. Aſcenſion	Am.	Braſil	S. Atl. Oce.	7 41 S.	13 31W	
I. Aſſinaria, Sardinia	Eu.	Italy	Medit. Sea	41 06N.	8 36 E.	
R. Aſhley	Am.	Carolina	Atl. Ocean	33 22N.	79 50W	
R. Aſiene	Af.	Guinea	S. Atl. Oce.	5 30N.	2 20W	
I. Aſtores	Af.	Madagaſ.	Ind. Ocean	10 22 S.	53 25 E.	
Athens	Eu.	Turkey	Archipelago	37 40N.	24 10 E.	
Atkin's Key	Am.	Bahama I.	Atl. Ocean	22 07N.	73 46W	
Atwood's Keys	Am.	Bahama I.	Atl. Ocean	21 22N.	72 40W	
C. Ava	Aſ.	Japon	S. Ocean	34 45N.	141 00 E.	
Is. Aves, Sotovent	Am.	Ter. Fir.	Atl. Ocean	11 30N.	66 43W	
C. St. Auguſtine	Am.	Braſil	Atl. Ocean	8 48 S.	35 00W	
C. St. Auguſtine	Aſ.	Mindanao	S. Ocean	6 40N.	126 25 E.	
St. Auguſtine	Am.	Florida	Atl. Ocean	30 15N.	80 29W	
Aydhab	Af.	Egypt	Red Sea	21 53N.	36 26 E.	
Aylah	Aſ.	Arabia	Red Sea	29 08N.	35 41 E.	
B						
Babelmondel Straits	Af.	Abyſſinia	Red Sea	12 50N.	43 50 E	
C. Baba	Aſ.	Natolia	Archipelago	39 33N.	26 22 E.	
I. Bachian	Aſ.	Moluca I.	S. Sea	00 40N.	123 00 E.	
I. Bahama	Am.	Baha. Is.	Atl. Ocean	26 45N.	78 35W	
Bahama Bank, N. pt.	Am.	Baha. Is.	Atl. Ocean	27 50N.	78 43W	
Balaſor	Aſ.	India	B. Bengal	20 00N.	79 54 E.	
Baldivia	Am.	Chili	S. Ocean	39 38 S	72 45W	
I. Bali	Aſ.	Sunda Is.	Ind. Ocean	8 05 S	114 30 E.	
Baltimore	Eu.	Ireland	W. Ocean	51 16N.	9 26W	4 30
I. Banca, S. end N. W. end	Aſ.	Sunda Is.	Ind. Ocean	3 15 S. 1 50 S.	107 10 E. 105 30 E.	
I. Banda	Aſ.	Moluc. Is	Ind. Ocean	04 30N.	127 25 E.	
Banjar	Aſ.	I. Borneo	Ind. Ocean	2 27 S.	113 50 E.	
Bantam	Aſ.	I. Java	Ind. Ocean	6 15 S.	106 25 E	
B. Bantry	Eu.	Ireland	Atl. Ocean	51 45N.	10 46W	
I. Barbadoes, Bridge town	Am.	Carib. Is.	Atl. Ocean	13 00N.	59 50W	
C. Barbas	Af.	Sanaga	N. Atl. Oce.	21 50N.	16 26W	
I. Barbuda	Am.	Carib. Is.	Atl. Ocean	18 06N.	61 35W	
C. Barcam	Eu.	Greenlnd.	N. Ocean	78 18N.	20 06 E.	
Barcelona	Eu.	Spain	Medit. Sea	41 26N.	2 18 E.	
C. Barfleur	Eu.	France	Eng. Chan.	49 38N.	1 16W	8 00
Bargazar Point	Eu	Iceland	N. Ocean	66 30N.	17 12W	
I. Bardſey	Eu.	Wales	St. Geo. Ch.	52 44N.	5 00W	
C. Barſo	Eu.	Ruſſia	White Sea	66 30N.	38 00 E.	

I. Ba

James of Places.	Con	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
Bartholomew	Am.	Carib. Is.	Atl. Ocean	17 52N.	62 35W	
de Bas	Eu.	France	Eng. Chan.	48 50N.	4 00W	3h. 45m.
aſſora	Af.	Arabia	Perſ. Gulf	29 45N.	47 40 E.	
.Baſſos, or Baxos	Af.	Anian	Ind. Sea	4 12N.	47 07 E.	
aſſos de Banhos	Af.	Zangueb.	Ind. Ocean	5 00 S.	48 08 E.	
aſſos de Chagos	Af.	India	Ind. Ocean	6 42 S.	68 20 E	
Baſſos des Indes	Af.	Zangueb.	Ind. Ocean	21 19 S.	41 43 E.	
atavia	Af.	I. Java	Ind. Ocean	6 15 S.	106 15 E.	
ayonne	Eu.	France	B. Biſcay	43 30N.	1 23 W	3 30
ayona Iſles	Eu.	Spain	Atl. Ocean	41 45N.	9 01W	
eachy Head	Eu.	England	Engl. Chan.	50 48N.	0 25 E.	6 00
ear-bay	Eu.	Greenlnd.	N. Ocean	79 10N.	24 15 E.	
Beerenberg	Eu.	———	N. Ocean	71 45N.	4 30 E.	
elfaſt	Eu.	Ireland	Iriſh Sea	54 43N.	5 52W	
ell Iſle	Eu.	France	B. Biſcay	47 21N.	3 13W	1 30
r. Bell Iſle	Am.	Newfland	Atl. Ocean	51 48N.	51 08W	
ell Sound	Eu.	Greenlnd	N. Ocean	77 15N.	12 40 E.	
encola	Af.	I. Sumat.	Ind. Ocean	4 00 S.	102 55 E.	
engal	Af.	India	B. Bengal	22 00N.	92 45 E.	
ergen	Eu.	Norway	W. Ocean	60 10N.	6 14 E.	
erlin	Eu.	Germany	R. Elbe	52 33N.	13 32 E.	
Bermudas	Am.	Baha. Is.	Atl. Ocean	32 25N.	66 38W	7 00
Bermaja	Am.	Mexico	G. Mexico	21 40N.	92 53W	
erwick	Eu.	England	Germ. Oce.	55 45N.	1 50W	1 30
erry Point	Eu.	England	Eng. Chan.	50 37N.	3 49W	
lboa	Eu.	Spain	B. Biſcay	43 26N.	3 18W	
ackney	Eu.	England	Germ. Oce.	53 20N.	0 55 E.	6 00
ack Point	Eu.	Greenlnd.	N. Ocean	78 00N.	10 50 E.	
ack Iſle	Eu.	No. Zem.	N. Ocean	72 52N.	52 35 E.	
. Blanco	Af.	Negrolnd.	Atl. Ocean	20 45N.	17 23W	9 45
Blanco	Am.	Patagonia	Atl. Ocean	47 07 S.	64 05W	
Blanco	Eu.	Greenlnd.	N. Ocean	77 58N.	20 04 E.	
Blanco	Am.	Mexico	S. Sea	9 42N.	85 55W	
Blanco, Sotovento	Am.	Ter.Firm.	Atl. Ocean	11 42N.	64 20W	
anchart Race	Eu.	France	Eng. Chan.	49 42N.	2 08W	0 00
aſques	Eu.	Ireland	Atl. Ocean	52 00N.	11 56W	
vet, or Port Louis	Eu.	France	B. Biſcay	47 45N.	3 13W	1 30
cachica	Am.	Ter.Firm.	Atl. Ocean	10 20N.	75 30W	
Bejador	Af.	Negrolnd.	Atl. Ocean	26 12N.	13 27W	0 00
Bolſhaya	Af.	Siberia	S. Sea	52 48N.	157 00 E.	
Bombay	Af.	India	Ind. Ocean	19 42N.	73 03 E.	
na	Af.	Tunis	Mediterran.	37 08N.	7 10 E.	
Bona	Af.	Tunis	Mediterran.	37 10N.	10 00 E.	
Bona viſta	Am.	Newfland	Atl. Ocean	49 36N.	50 10W	
Bona viſta	Af.	C. Verd I.	Atl. Ocean	10 05N.	21 50W	
Bona fortuna	Eu.	Ruſſia	White Sea	65 35N.	38 25 E	
on ayre, Sotovento	Am.	Ter. Firm	Atl. Ocean	11 52N.	67 20W	
Bonavèntura	Am.	Ter. Firm.	S. Sea	3 18N.	76 50W	
Bon Eſperance	Af.	Caffers	Ind Ocean	34 15N.	20 07 E.	3 00
urdeaux	Eu.	France	B. Biſcay	44 50N.	0 40W	3 00

S. Borneo

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Wate
				° ′	° ′	
Iſl. Borneo { Eaſt. point	Aſ.		Ind. Ocean	1 12N.	117 10E.	
Weſt. point				3 15N	108 57E.	
North. point				7 05N.	113 40E.	
South. point				3 32 S.	112 05 E.	
Borneo				5 00N.	112 15 E.	
Succadano				0 50 S.	108 35 E.	
I. Bornholm	Eu.	Sweden	Balt. Sea	55 12N.	15 50 E.	
Boſton	Eu.	England	Germ. Oce.	53 10N.	0 25 E	
Boſton	Am.	New Eng.	Atl. Ocean	42 34N.	70 25 W	
Boulogne	Eu.	France	Eng. Chan.	50 44N.	1 42 E.	10h. 30
I. Bourbon	Af.	Madagaſ.	Ind. Ocean	21 15 S.	55 40 E	
I. St. Brandon	Af.	Madagaſ.	Ind. Ocean	16 45 S.	64 48 E	
B. Brandwyns	Eu.	Greenlnd.	N. Ocean	79 50N.	26 20 E.	
I. Bravas	Af.	C. Verd I.	Atl. Ocean	14 30N.	23 44 W	
Bremen	Eu.	Germany	R. Weſer	53 30N.	9 00 E.	6 00
Breeſound, a ſand	Eu.	Dutchlnd.	Germ. Oce.	53 12N.	5 15 E.	4 30
Breſlau	Eu.	Sileſia	R. Oder	51 03N.	17 13 E	
Breſt	Eu.	France	B. Biſcay	48 23N	4 26W	3 45
B. Breſt	Am.	New Brit.	W. Ocean	52 10N.	52 30W	
Bridge Town	Am.	I. Barbad.	Atl. Ocean	13 00N	59 50 E.	
Bridlington Bay	Eu.	England	Germ. Oce.	54 07N.	00 04 E.	3 45
Brill	Eu.	Dutchlnd.	Germ. Oce.	51 56N.	4 10W	
Briſtol	Eu.	England	St. Geo. Ch.	51 28N.	2 30W	6 45
I. Cape Britain { Louiſbourg	Am.	Acadia	Atl. Ocean	45 50N.	58 27W	
I. Scateri				46 00N.	57 47W	
N. Cape				47 06N.	58 02W	
New Britain { I. Mathias	Af.	New Guinea	S. Ocean	2 00 S.	147 50 E.	
N. point				2 30 S.	148 40 E	
S. W. point				6 00 S.	146 37 E.	
Str. Dampier				6 15 S	146 15 E.	
C. St. George				5 30 S.	150 55 E	
I. St. John				4 20 S.	152 40 E.	
Buchaneſs	Eu.	Scotland	Germ. Oce.	57 29N	1 23W	3 0[illegible]
Buenos Ayres	Am.	Braſil	Atl. Ocean	34 35 S	57 40W	
Burgaford point	Eu.	Iceland	N. Ocean	66 03N.	16 34W	
Burlings, rocks	Eu.	Portugal	Atl. Ocean	39 30N.	9 13W	
Burlington	Eu.	England	Germ. Oce.	54 00N.	0 08 E.	
Button's Iſles	Am.	New Brit.	Hudſ. Str.	60 25N.	65 00W	
C						
I. Cabrera	Eu.	Italy	Mediterran.	43 10N.	9 11 E.	
Cadiz	Eu.	Spain	Atl. Ocean	36 33N.	6 02W	4 30
Caen	Eu.	France	Eng Chan.	49 11N	0 16W	9 00
Cagliari, I. Sardin.	Eu.	Italy	Med. Sea	39 25N	9 38 E.	
Calabar { Old	Af	Guiney	Eth. Ocean	4 30N	8 10 E.	
New				5 00N	7 00 E.	
C. Calaberno	Aſ.	Natolia	Archipelago	38 42N.	26 44 E.	
Calais	Eu.	France	Eng. Chan.	50 58N.	01 56 E.	4 30
C. Calamadon	Aſ.	India	B. Bengal	10 22N.	80 40 E.	

Calde

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
Caldera	Aſ.	I. Mindanao	S. Ocean	7 00N.	121 25 E.	
. Caldy	Eu.	England	St. Geo. Ch.	51 33N	5 14W	5h. 15m.
Calecut	Aſ.	India	Ind. Ocean	11 15N	75 39 E.	
s. Caicos, or Cankroſs, N. part	Am.	Bahama I.	Atl. Ocean	21 48N	71 50W	
airo	Af.	Egypt	R. Nile	30 02N.	31 31 E.	
. Great Camanis	Am.	W. Indies	Atl. Ocean	19 18N.	80 29W	
. Little Camanis	Am.	W. Indies	Atl. Ocean	19 42N.	79 20W	
Camboida	Aſ.	India	Ind. Ocean	10 35N	104 45 E.	
. Cambron, or Carbon	Af.	Algiers	Med. Sea	37 18N.	4 58 E.	
. Cameron	Am.	NewSpain	Atl. Ocean	15 35N	83 29W	
. Camerones	Af.	Guiney	Atl. Ocean	3 30N.	9 10 E.	
. Camerones	Am.	Magellan	Atl. Ocean	44 50 S.	64 10W	
amfer, a ſand	Eu.	Dutchlnd.	Germ. Oce.	53 33N	5 30 E	1 30
amin	Eu.	Germany	Baltic Sea	54 04N	15 40 E.	
ampeachy	Am.	Yucatan	Atl. Ocean	19 36N.	90 53W	
Canaria	Af.	Canaries	Atl. Ocean	28 07N.	14 26W	
. Candenoſe	Eu.	Ruſſia	N. Ocean	69 25N.	45 30 E.	
C. St. John, W. end Candia C. Salomon, Eaſt end	Eu.	Turkey	Medit. Sea	35 12N. 35 19N. 34 57N.	23 54 E. 25 23 E. 27 06 E.	
andia	Aſ.	I. Ceylon	Ind. Ocean	7 54N.	81 53 E.	
Candu	Aſ.	India	Ind. Ocean	7 30 S	77 55 E.	
. Canſo	Am.	Nov.Scot.	Atl. Ocean	45 10N.	59 50W	
anſo Paſſage	Am.	Nov.Scot.	Atl. Ocean	45 50N	60 00W	
. Cantin	Af.	Barbary	Atl. Ocean	32 49N	9 09W	0 00
antire, Mul	Eu.	Scotland	Weſt. Ocean	55 22N	5 45W	
anton	Aſ.	China	S. Ocean	23 08N.	113 08 E.	
Capri	Eu.	Italy	Medit. Sea	40 34N	14 11 E.	
Capraya	Eu.	Italy	Medit. Sea	43 03N	10 15 E.	
Carapar	Aſ.	India	B. Bengal	19 22N.	86 05 E.	
araccas	Am.	Ter.Firm.	Atl. Ocean	10 06N.	66 45W	
aries, or Hacluits Iſles	Am.	Groenlnd.	Baffing Bay	77 15N	62 00W	
arinda Point	Am.	California	S. Ocean	38 24N.	124 25W	
arliſlè	Eu.	England	Iriſh Sea	54 47N	2 35W	
Carmel	Aſ.	Syria	Levant	33 08N.	35 35 E.	
aroline Iſles, limits	Aſ.	Phil. Iſles	South Sea	7 10N 12 00N.	137 25 E. 127 25 E.	
Carthage	Af.	Barbary	Medit. Sea	36 52N	10 31 E.	
rthagena	Am.	Ter. Fir.	Carib. Sea	10 27N	75 21W	
arthagene	Eu.	Spain	Medit. Sea	37 37N.	1 03W	8 1
aſkets	Eu.	I Guernſ.	Eng. Chan.	49 50N	2 26W	
Caſſander	Eu.	Turky	Archipelago	40 02N.	23 41W	
St. Catherines	Am.	Braſil	Atl. Ocean	27 45N	47 58W	
t Iſle N. pt. S. pt.	Am.	Bahama	Atl. Ocean	24 50N 23 48N.	75 38W 75 35W	

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud	H. Wate
				° '	° '	
Cathneſs Point, or Dinnet Head	Eu.	Scotland	Weſt. Ocean	58 46N.	3 17W	9h. 00
Catanea	Eu.	I. Sicily	Medit. Sea	42 40N.	20 30 E.	
C. Catocha	Am.	NewSpain	Carib. Sea	20 48N.	86 35W	
Cayenne	Am.	Ter.Firm.	Atl. Ocean	4 56N.	53 05W	
I. Celebes N. E. point	Aſ.	Spice Iſles	Ind. Ocean	1 48N.	124 37 E.	
N. point				1 40N.	120 50 E.	
W. point				3 00 S.	117 55 E.	
S. W. point, Macaſſer				4 40 S	119 05 E.	
S. point				5 40 S.	119 55 E.	
S. E. point				5 00 S.	121 40 E.	
I. Cephalonia	Eu.	Turkey	Medit. Sea	38 20N.	20 11 E.	
Ceuta	Af.	Barbary	Medit. Sea	35 45N.	4 42W	
I. Ceylon Iafanapatam N. part	Aſ.	India	Ind. Ocean	9 47N.	80 55 E.	
Trinquemale S. E. end				8 40N.	81 40 E.	
C. Gallo, S. W. end				6 27N.	82 10 E	
				6 15N.	80 20 E.	
Chandenagar	Aſ.	Bengal	R. Ganges	22 51N.	88 34 E.	
Charles Town	Am.	Carolina	Aſhley R.	33 22N.	79 50W	
C. Charles	Am.	Virginia	Atl. Ocean	37 11N.	76 07W	
C. Charles	Am.	N. Main	Hudſ. Str.	62 20N.	74 30W	
C. Charles	Am.	New Brit	W. Ocean	51 50N.	51 10W	
I. Charlton	Am.	New Wls	Hudſ. Bay	52 30N	82 00W	
B. Chebucto	Am.	Nov.Scot.	Atl. Ocean	44 45N.	63 18W	
Cheignecto	Am.	Nov.Scot.	B. Fundy	46 15N.	63 11W	
Cherbourg	Eu.	France	Engl. Chan.	49 38N.	01 33W	7 00
Cherry Iſle	Eu.	Greenlnd.	N. Ocean	74 35N.	18 05 E.	
Cheſter	Eu.	England	Iriſh Sea	53 10N	2 25W	
Chiddock	Eu.	England	Engl. Chan.	50 47N.	3 00W	
C. Chidley	Am.	New Brit	Hudſ. Str.	60 22N.	65 00W	
I. Chiloe N. pt S. pt.	Am.	Patagonia	S. Sea	41 45 S. 43 50 S	73 05W	
C. Chiokotſkago	Aſ.	Siberia	N. Ocean	64 00N.	174 45W	
Chriſtiana	Eu.	Norway	Sound	59 25N.	10 30 E.	
Chriſtianople	Eu.	Sweden	Baltic Sea	55 55N.	15 10 E.	
Chriſtianſtadt	Eu.	Sweden	G. Bothnia	62 47N.	22 50 E.	
I. St. Chriſtophr's	Am.	Carib. I.	Atl. Ocean	17 15N.	62 50W	
R. St. Chriſtophr's	Af.	Caffres	Ind. Ocean	32 47 S.	30 00 E.	
C. Chukchenſe	Aſ.	Siberia	N. Ocean	66 30N.	171 10W	
R. Churchil	Am.	New Wls.	Hudſ. Bay	59 03N.	95 35W	
I. Chuſan	Aſ.	China	Chineſe Sea	30 00N	121 50 E.	
Civita Vecchia	Eu.	Italy	Medit. Sea	42 10N.	12 01 E.	
C. Clear	Eu.	Ireland	Weſt. Ocean	51 18N.	9 50W	4 30
I. Cloate	Aſ.	India	Ind. Ocean	22 00 S.	95 40 E	
Cochin	Aſ.	India	Ind. Ocean	9 50N.	76 05 E	
I. Cocos	Aſ.	India	Ind. Ocean	12 20 S.	98 10 E.	
I. Cocos	Am.	Mexico	S. Ocean	5 00N.	88 45W	

C. C

ames of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° '	° '	
Cod	Am.	New Eng.	Atl. Ocean	42 15N.	69 27W	
lcheſter	Eu.	England	Germ. Oce.	52 00N.	0 58E.	
Cold	Eu.	Greenlnd.	N. Ocean	79 00N.	10 00E.	
Colerado	Am.	NewSpain	G Californ	31 40N	115 25W	
Colgau	Eu.	Ruſſia	N. Ocean	69 20N	45 00E.	
llioure	Eu.	Spain	Medit. Sea	42 31N.	3 10E.	
Colone	Eu.	Turkey	Archipelago	37 43N.	24 41E.	
Colone	Af.	Natolia	Archipelago	39 10N.	27 04E.	
Colonni	Eu.	Italy	Medit. Sea	38 56N.	18 05E	
mana	Am.	Ter.Firm.	Atl. Ocean	10 00N.	65 07W	
Comarin	Af.	India	Ind. Ocean	7 45N.	78 17E.	
Comfort	Am.	New Wls.	Hudſ. Bay	64 45N.	82 30W	
ncarneau	Eu.	France	B. Biſcay	47 54N.	3 50W	3h. 00m.
Conception	Am.	Caleforn.	South Sea	35 40N.	126 01W	
Conceptn. Ent	Am.	Newf Ind.	Atl. Ocean	48 25N.	50 07W	
nception	Am.	Chili	South Sea	36 43S.	73 07W	
Congo	Af.	Congo	Eth. Ocean	5 45S.	11 53E.	
Coningen	Af.	NewZeld.	S. Ocean	34 30S.	164 25E.	
ningſburg	Eu.	Poland	Baltic Sea	54 44N.	21 53E.	
nquet	Eu.	France	Engl. Chan.	48 30N	4 35W	3 00
Conquibaco	Am.	Ter Firm.	Atl. Ocean	12 15N.	69 57W	
nſtantinople	Eu.	Turkey	Archipelago	41 00N.	28 58E.	
penhagen	Eu.	Denmark	Baltic Sea	55 41N.	12 50E	
perwic	Eu.	Norway	Sound	59 20N.	10 10E	
Copland	Eu.	Ireland	Iriſh Sea	54 40N.	6 40W	
Coquet	Eu.	England	Germ. Oce.	55 20N.	1 25W	3 00
Coquimbo	Am.	Chili	S. Ocean	29 54S.	71 10W	
Corbau	Af.	Natolia	Archipelago	38 03N.	26 58E.	
rdoue	Eu.	France	B. Biſcay	45 30N.	01 10W	
rea, South lim.	Af.	China	S. Ocean	34 50N.	124 25E 127 25E	
Corfu	Eu.	Turkey	Mediterran.	39 50N.	19 48E.	
Corientes	Af.	Caffers	Ind. Ocean	24 08S.	36 49E.	
Corientes	Am.	Mexico	S. Ocean	20 18N	108 00W	
rinth	Eu.	Turkey	Archipelago	37 30N.	23 00E	
rk	Eu.	Ireland	St. Geo. Ch.	51 45N.	7 30W	4 30
Corſe	Af.	Guiney	Eth. Sea	5 12N.	0 23W	3 30
C. Corſo, N. pt. Bonfacio, S pt.	Eu.	Italy	Mediterran.	42 53N. 41 22N.	9 40E. 9 26E.	
Corvo	Eu.	Azores	Atl. Ocean	39 48N.	31 22W	
Coſmoledo	Af.	Madagaſ.	Ind. Ocean	10 28S.	51 40E.	
w and Calf	Eu.	Ireland	W. Ocean	51 22N.	0 36W	
Cozumel	Am.	Jucatan	Atl. Ocean	19 36N	86 35W	
Crocei	Af.	China	B. Nankin	34 06N.	120 10E.	
omer	Eu.	England	Germ. Oce.	53 05N.	0 56E	6 00
ooked I. N. pt.	Am.	Bahama	Atl. Ocean	22 47N.	73 50W	
oſs Iſle	Eu.	Ruſſia	White Sea	66 31N.	36 33E.	
oſs Point	Eu.	Nov. Zem	N. Ocean	72 00N.	53 12E	
Cruz	Af.	Barbary	Atl. Ocean	30 36N.	9 35W	

St. Cr

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud	H Water
				° ′	° ′	
I. St. Cruz	Am.	Antilles I	Atl. Ocean	17 55N.	65 02W	
Iſl. Cuba	Am.	Antilles I.	Atl. Ocean			
C. Antonio, W. pt.				21 45N	84 05W	
P. de Mais, E. pt.				20 03N	74 52W	
HollowCape				19 42N.	77 25W	
St. Jago				20 03N.	75 51W	
St. Mary				21 26N	78 10W	
Le St. Eſprit				21 56N.	79 50W	
Havana				23 12N.	81 45W	
B. Hondy				22 54N	82 40W	
Cubbs Iſles	Am	New Wales	Hudſ. Bay	54 15N.	82 34W	
Cubello	Aſ.	Ind. Malab.	Ind. Ocean	7 50N.	71 55 E.	
B. Cumberland	Am.	N. Main	Davis's Str.	66 40N.	65 20W	
Curaſſo	Am.	Ter Firm	Atl. Ocean	11 56N	68 20W	
I. Cuzzola	Eu.	Turkey	Med. Sea	42 50N	16 55 E.	
Cuſco	Am.	Peru	Inland	12 25 S.	73 35W	
I. Cyprus	Aſ.	Syria	Medit. Sea			
C. Baſſa, W. end				35 04N	33 04 E.	
C. St. Andr. E. end				35 40N	35 08 E.	
C. de Gaſſe, S. pt.				34 35N	33 41 E.	
C. Grego, S. E. pt.				34 57N.	34 36 E.	
D						
Dabul	Aſ	India	Arab. Sea	18 24N.	73 33 E.	
Dahlak	Aſ.	Arabia	Red Sea	15 50N.	41 44 E.	
I. Dageroort, Light-houſe	Eu.	Livonia	Balt. Sea	58 55N	22 32 E.	
Dantzic	Eu.	Poland	Balt. Sea	54 22N.	18 36 E.	
Str. Dardanels	Eu.	Turkey	Archipelago	40 10N	26 26 E.	
G Darien	Am.	Ter Firm.	Carib. Sea	8 45N	76 35W	
Dartmouth	Eu.	England	Eng. Chan.	50 27N.	3 36W	5h. 15
I. Dauphin	Am.	Louiſiana	G. Mexico	29 40N	87 53W	
St. David's Head	Eu.	Wales	St, Geo. Ch.	51 55N.	5 22W	6 00
Fort St. David's	Aſ.	India	Corom Coaſt	12 05N	80 55 E.	
I. Deſeada	Am.	Carib. Is.	Atl. Ocean	16 36N	61 15W	
C. Deſire	Eu.	No. Zem	N. Ocean	77 45N.	79 20 E.	
C. Deſolation	Am	Greenlnd	N. Ocean	61 45N	47 00W	
Devil's Iſles	Eu.	Greenlnd.	N. Ocean	80 00N.	11 43 E.	
Dewpoint	Aſ.	India	B. Bengal	16 07N	81 47 E.	
I. Diego Royes	Aſ.	Ind. Malab.	Ind. Ocean	0 45 S. 0 30N	70 25 E	
I. Diego Garcia	Aſ.	India	Ind. Ocean	8 45 S	68 10 E.	
Str. Diemen	Aſ	Japan Is.	S. Ocean	31 12N.	130 55 E.	
I. Dieu	Eu.	France	B. Biſcay	46 26N.	2 20W	
Diep	Eu.	France	Eng Chan.	49 55N	1 09 E.	9 45
Diggs's, or Dudley's Cape	Am	Greenlnd	Baffins Bay	76 48N	59 07W	

Po. D

ames of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
. Diu	Af.	India	Ind. Ocean	21 37N.	70 28 E.	
Dobbs	Am.	North Wales	Hudſ. Bay	65 00N.	81 25W	
ofare	Af.	Arabia	Ind. Ocean	16 24N.	53 40 E.	
. Dominga Hiſpaniola	Am.	Antilles	Atl. Ocean	18 25N.	69 30W	
Dominico	Am.	Caribbe	Atl. Ocean	15 15N.	61 08W	
orderecht	Eu.	Dutchlnd.	R. Maes	52 00N.	4 26 E.	
Dorfui	Af.	Ajan	Ind. Ocean	10 15N.	50 44 E.	
Doro	Eu.	Turkey	Archipelago	38 02N.	25 12 E	
ort	Eu.	Dutchlnd	Germ. Oce.	51 47N.	4 40 E.	3h. 00m.
Doſel	Eu.	Livonia	Balt. Sea	58 20N.	23 00 E	
. Dos Banhos	Af.	Zangueb.	Ind. Ocean	5 15N.	49 24 E.	
over	Eu.	England	Eng. Chan.	51 07N.	1 13 E.	0 00
owns	Eu.	England	Germ. Oce.	51 25N.	1 21 E.	2 15
. Dradate	Af.	Egypt	Red Sea	19 56N.	37 40 E.	
. Drake, Sir Francis	Am.	California	S. Sea	38 45N.	128 35W	
ronthem	Eu.	Norway	N. Ocean	63 16N.	10 55 E.	
ublin	Eu.	Ireland	Iriſh Sea	53 12N.	6 55W	8 15
unbar	Eu.	Scotland	Germ. Oce.	55 58N.	2 22W	4 30
undalk	Eu.	Ireland	Iriſh Sea	53 57N.	6 28W	
undee	Eu.	Scotland	Germ. Oce.	56 26N.	2 48W	2 15
ungarvan	Eu.	Ireland	Atl. Ocean	51 57N.	7 55W	4 30
ungeneſs	Eu.	England	Engl. Chan.	51 00N.	0 51 E.	9 45
ungſbay Head	Eu.	Scotland	Germ. Oce.	58 45N.	2 57W	
unkirk	Eu.	France	Germ. Oce.	51 02N.	2 27 E.	0 00
unnoſe	Eu.	I. Wight	Eng. Chan.	50 38N.	1 23W	9 45
urazzo	Eu.	Turkey	Mediter. Sea	41 58N.	25 00 E.	
E						
dinburgh	Eu.	Scotland	Germ. Oce.	55 58N.	3 00W	4 30
dyſtone	Eu.	England	Engl. Chan.	50 12N.	4 20W	7 30
Elba	Eu.	Italy	Mediterran.	42 52N.	10 38 E.	
. Elbe mouth	Eu.	Germany	Germ. Oce.	54 18N.	7 10 E.	0 00
lbing	Eu.	Poland	Balt. Sea	54 12N.	20 35 E.	
lſingburg	Eu.	Sweden	Balt. Sea	56 00N.	13 35 E.	
lſinore	Eu.	Denmark	Balt. Sea	56 00N.	13 23 E.	
Eluthe- N.pt. ria S. pt.	Am.	Bahama	Atl. Ocean	25 45N. 24 57N.	76 42W 75 53W	
mbden	Eu.	Germany	Germ. Oce.	53 05N.	7 26 E	0 00
. Emes mouth	Eu.	Germany	Germ. Oce.	53 10N.	7 20 E.	7 30
nchuyſen	Eu.	Dutchlnd.	Zuyder Sea	52 43N.	5 06 E.	0 00
Engano, or Trompeuſe	Af.	Siam	Ind. Ocean	6 00 S.	102 35 E.	
. Enhorn	Eu.	Greenlnd.	N. Sea	78 45N.	26 05 E	
pheſus	Af.	Natolia	Archipelago	38 00N.	27 53 E	
ſtaples	Eu.	France	Engl. Chan.	50 34N.	1 42 E.	11 00
. Exuma	Am.	Bahama	Atl. Ocean	23 25N.	75 35W	

Fairhead

Names of Places.	Con	Countries.	Coaſt.	Latitude.	Longitud.	H. Wate
				° '	° '	
F						
Fairhead	Eu.	Ireland	W. Ocean	55 19N.	6 20W	
C. Falcon	Af.	Barbary	Medit. Sea	36 03N.	0 14W	
I. Falkland { E. end	Am.	Patagon	Atl. Ocean	51 30 S.	55 40W	
Iſl. A niſant				52 15 S.	56 47W	
Falmouth	Eu.	England	Eng. Chan.	50 12N.	5 12W	4h. 30
C. Falo	Eu.	Turkey	Archipelago	40 12N.	24 27E	
C. Falſo	Af.	Zangueb.	Ind. Ocean	8 52 S.	39 55 E.	
Falſterbom	Eu.	Sweden	Balt. Sea	55 20N.	13 36 E.	
I. Fana	Eu.	Turkey	Medit. Sea	40 14N	19 32 E.	
R. Farate	Af.	Egypt	Red Sea	21 40N.	36 29 E.	
Faro Head, or C. Wrath	Eu	Scotland	W. Ocean	58 44N.	4 50 W	
C. Farewell	Am.	Greenlnd.	N. Ocean	59 37N.	44 30W	
C. Fartack	Af.	Arabia	Ind. Ocean	15 41N.	51 31 E.	
C. Fear	Am.	Carolina	Atl. Ocean	34 04N.	78 09W	
I. Fernando Noranha	Am.	Braſil	Atl. Ocean	3 50 S.	30 35W	
I. Felicur, Lipari Iſles	Eu.	Italy	Medit. Sea	38 33N.	14 51 E	
I. Fermina	Eu.	Turkey	Archipelago	37 24N.	25 05 E.	
I. Fernandepo	Af.	Guiney	Atl. Ocean	3 02N.	3 33 E.	
I. Ferro	Af.	Canaries	Atl. Ocean	27 48N.	17 26W	
C. Finiſterre	Eu.	Spain	Atl. Ocean	43 15N.	9 20W	
I. Fironda	Af.	Corea	South Sea	33 30N.	127 25 E.	
Flamborough Head	Eu.	England	Germ.Ocean	54 08N.	0 11 E.	3 00
I. Flores	Eu.	Azores	Atl. Ocean	39 23N.	30 22W	
C. Florida	Am.	Florida	G. Mexico	25 50N.	80 20 W	7 30
Fluſhing	Eu.	Dutchlnd.	Germ.Ocean	51 33N.	3 20 E.	0 45
I. Fly	Eu.	Dutchlnd.	Germ.Ocean	53 16N	5 35 E.	7 30
Forbiſher's Straits	Am.	Groenlnd.	Atl. Ocean	62 05N.	47 18W	
N. Foreland	Eu.	England	Germ. Oce.	51 28N.	1 10 E.	9 45
S. Foreland	Eu.	England	Eng. Chan.	51 12N.	1 18 E.	9 45
Foreland Fair	Eu.	Ireland	N. Ocean	55 05N.	6 30W	
Foreland Fair	Eu.	Greenlnd.	N. Ocean	79 18N.	10 50 E.	
Foreland Merchts.	Am.	Greenlnd.	N. Ocean	63 20N.	17 05W	
I. Formentaria	Eu.	Spain	Medit. Sea	38 33N.	1 15 E.	
I. Formigo	Eu.	Azores	Atl. Ocean	37 55N.	21 50W	
C. Formoſa	Af.	Guiney	Eth. Sea	4 22N.	5 43 E.	
R. Formoſa	Af.	Guiney	Eth. Sea	6 10N.	4 49 E.	
I. Formoſa { N. pt.	Af.	China	Ind. Ocean	25 25N.	121 25 E.	
S. pt.				22 00N.	120 40 E.	
I. Forteventura, S. W. end	Af.	Canaries	Atl. Ocean	28 22N.	13 25W	
Foulneſs	Eu.	England	Germ. Oce.	52 57N	0 58 E.	6 45
Foulſound	Eu.	Greenlnd.	N. Ocean	77 30N.	12 50 E.	
Foye	Eu.	England	Eng. Chan.	50 25N.	4 30W	5 15
C. St. Francis	Am.	Peru	S. Sea	0 30N.	80 35W	
I. St. Franciſco	Af.	Zanguebar	Ind. Ocean	6 23 S.	53 22 E.	
R. St. Franciſco	Am.	Braſil	Atl. Ocean	10 55 S.	36 30W	

ames of places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
rederickſtadt	Eu.	Norway	Sound	59 00N.	11 10E.	
. French Keys	Am.	Bahama	Atl. Ocean	22 30N.	73 40W	
etum Borough	Eu.	Ruſſia	N. Ocean	70 00N.	61 20E	
. Frio	Am.	Braſil	Atl. Ocean	23 00 S.	40 11W	
. Fugor	Af.	Zangueb.	Ind. Ocean	00 10N.	42 05 E	
Fuego	Af.	De Verd	Atl. Ocean	14 55N.	23 28W	
. Fuſhan	Af.	China	S. Sea	23 00N.	112 35E.	
Fyal	Eu.	Azores	Atl. Ocean	38 38N.	27 05W	
G						
Galla	Am.	Terra Fir.	S. Sea	2 40N.	79 35W	
Gallega	Am.	Patagon	Atl. Ocean	51 37 S.	65 35W	
Gallego	Am.	Ter. Fir.	S. Sea	1 40N.	104 35W	
allipoli	Eu.	Italy	Medit. Sea	40 19N.	18 08E.	
allipoly	Eu.	Turkey	Archipelago	40 36N.	27 02E.	
Gallita	Af.	Barbary	Medit. Sea	37 42N.	9 03E.	
. Gallo	Af.	I. Ceylon	Ind. Ocean	6 15N.	80 20E.	
. Gallopega	Am.	Peru	South Sea	2 00N. 2 00 S.	89 00W	
ally Head	Eu.	Ireland	W. Ocean	52 40N.	9 30W	
alway	Eu.	Ireland	W. Ocean	53 10N.	10 03W	
. Gambia	Af.	Negrolnd.	Atl. Ocean	13 00N.	14 58W	
Gamo	Af.	India	Ind. Ocean	3 05 S.	77 25E.	
. Gardafuy	Af.	Anian	Ind. Ocean	11 48N.	50 25E.	
. Garonne	Eu.	France	B. Biſcay	45 30N.	1 05W	3h. 00m.
. de Gatt	Eu.	Spain	Medit. Sea	36 32N.	2 05W	
. Gear	Af.	Barbary	Atl. Ocean	30 35N.	10 01W	
enoa	Eu.	Italy	Medit. Sea	44 25N.	8 41E.	
St. George	Am.	Newfland	Atl. Ocean	48 19N.	56 00W	
St. George	Af.	Natolia	Archipelago	38 47N.	25 07E.	
St. George	Eu.	Azores	Atl. Ocean	38 45N.	25 55W	
. George's Fort	Af.	India	Bengal B.	13 15N.	80 50E.	
ibralter	Eu.	Spain	Medit. Sea	36 13N.	4 53W	0 00
Gilolo N. pt.	Af.	Spice Is.	Ind. Ocean	2 30N.	128 00E.	
Gilolo S. pt.				1 30 S.	129 25E.	
laſcow	Eu.	Scotland	R. Clyd	55 52N.	4 05W	
oa	Af.	India	Arab. Sea	15 31N.	73 50E.	
oes	Eu.	Dutchlnd.	Germ. Oce	51 39N.	4 05E.	
olfe triſte	Am.	Ter. Fir.	Carib. Sea	10 20N.	67 40W	
ombroon	Af.	Perſia	Perſ. Gulf	27 40N.	55 20E.	
Gomero	Af.	Canaries	Atl. Ocean	28 08N.	16 35W	
. Gondewar	Af.	India	B. Bengal	16 55N.	82 55E.	
. Good Hope	Af.	Caffers	Ind. Ocean	34 15 S.	20 07E.	3 00
Gorea	Af.	Negrolnd.	Atl. Ocean	14 40N.	17 00W	
Gorgona	Eu.	Italy	Medit. Sea	43 21N.	9 11E	
land N. end	Eu.	Sweden	Balt. Sea	58 00N.	20 15E	
land S. end				56 58N.	19 37E.	
land Wiſby				57 40N.	19 50E.	
Goto	Af.	Corea	South Sea	34 25N	125 50E.	
ottenberg	Eu.	Sweden	Sound	57 45N	12 15E	

R. Grand

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Wate
				° ′	° ′	
R. Grand	Am.	Paraguay	Atl. Ocean	31 58 S	50 35W	
Granville	Eu.	France	Eng. Chan.	48 50N.	1 32W	7h. 00
I. Gratioſa	Af.	Canaries	Atl. Ocean	29 37N.	12 08W	
I. Gratioſa	Eu.	Azores	Atl. Ocean	39 06N.	26 10W	
C. Gratios a dios	Am.	NewSpain	Carib. Sea	14 48N.	82 15W	
Graveline	Eu.	France	Eng. Chan.	50 59N.	2 13 E.	0 00
Graveſend	Eu.	England	R. Thames	51 35N.	0 20 E.	1 30
I. Grenada	Am.	Caribbe	Atl. Ocean	11 52N.	61 39W	
Greenwich	Eu.	England	R. Thames	51 28N.	0 05 E.	
C. Gremia	Eu.	Turkey	Archipelago	40 33N.	26 20 E.	
Gripſwald	Eu.	Germany	Bal. Sea	54 14N.	15 34 E.	
Grimeſby	Eu.	England	Germ. Oce.	53 30N.	0 56 E.	
Groin, or C. Corunna	Eu.	Spain	B. Biſcay	43 28N.	9 20W	3 00
I. Groy	Am.	Newfland	Atl. Ocean	50 39N.	51 35W	
I. Guardaloupe	Am.	Caribbe	Atl. Ocean	16 20N.	61 25W	
Guayaquil	Am.	Peru	S. Sea	2 10 S	80 10W	
I. Guernſey	Eu.	England	Eng. Chan.	49 30N.	2 47W	0 45
Gulf	Eu.	England	St. Geo. Ch	50 06N.	6 00W	
H						
Hacluit's Headland	Eu.	Greenlnd.	N. Ocean	79 55N.	12 00E.	
I. Hainam N.E. pt	Af.	China	Ind. Ocean	19 45N.	110 13E.	
I. Hainam S.W. pt				18 22N.	108 13 E.	
I. Hall	Am.	Groenlnd.	Atl. Ocean	63 56N.	44 26W	
Halliford	Eu.	Iceland	N. Ocean	64 30N.	27 15W	
Hambourgh	Eu.	Germany	R. Elbe	53 41N.	10 38 E.	6 00
Harlem	Eu.	Dutchlnd.	Germ. Oce.	52 24N.	4 10 E.	9 00
Hartland Point	Eu.	England	Briſtol Ch.	51 06N.	4 35W	
Hartlepool	Eu.	England	Germ. Oce.	54 40N.	0 56W	3 00
Harwich	Eu.	England	Germ. Oce.	52 11N.	1 18 E.	11 15
C. Hatteras	Am.	Carolina	Atl. Ocean	35 24N.	76 20W	
Havannah	Am.	I. Cuba	Atl. Ocean	23 12N.	81 11W	
Havre de Grace	Eu.	France	Eng. Chan.	49 30N.	0 17 E.	9 00
I. St. Helena	Af.	Caffers	Atl. Ocean	16 00 S.	5 53W	
Helie's Sound	Eu.	Greenlnd.	N. Ocean	79 15N	12 50E	
Is. Heligh Land	Eu.	Norway	N. Ocean	65 15N.	9 30 E.	
C. Henrietta	Am.	New Wales	Hud. Bay	55 08N.	84 25W	
C. Henry	Am.	Virginia	Atl. Ocean	36 57N.	76 23W	
I. Heys	Eu.	France	B. Biſcay	46 24N	2 14W	
High Mount	Eu.	Greenlnd.	N. Ocean	83 23N.	26 40E	
C. Hinlopen	Am.	Maryland	Atl. Ocean	39 10N.	74 50W	
Iſl. Hiſpanolia C. Tiberon, W. pt.	Am.	Antilles	Atl. Ccean	18 17N	74 30W	
C. St. Nichol. N. W. pt.				19 50N.	73 08W	
Po. Grave				18 28N.	72 42W	
St. Domingo				18 25N.	69 30W	
C. Raphael N. E. pt.				19 05N	68 30W	

R. Hegſ

ames of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
Hogſties	Am.	Bahama	Atl. Ocean	21 41N.	73 15W	
Holland { B. Seadogs				25 33 S.	108 10 E.	
N. W. limit	Af.		Ind. Ocean	20 30 S.	112 15 E.	
S. W. limit				34 45 S.	112 00 E.	
ly Cape	Af.	Siberia	N. Ocean	72 32N.	179 45 E.	
ly Head	Eu.	Wales	Iriſh Sea	53 23N.	4 40W	
Honduras	Am.	NewSpain	Carib. Sea	16 18N.	85 23W	
Hondy, I. Cuba	Am.	Antilles	Atl. Ocean	22 54N.	82 40W	
nfleur	Eu.	France	R. Seine	49 24N.	0 20 E.	
pe Iſle	Eu.	Greenlnd.	N. Ocean	76 22N.	23 40 E.	
Horn	Am.	Ter. Fuego	S. Ocean	55 42 S.	66 00W	
rnſound	Eu.	Greenlnd.	N. Ocean	76 41N.	13 36 E	
Hougue	Eu.	France	Engl. Chan.	49 45N.	1 55W	
Hughley	Af.	India	B. Bengal	21 45N.	89 15 E	
ll	Eu.	England	R. Humber	53 50N.	0 28W	6h. 00m.
Humber, Ent.	Eu.	England	Germ. Oce.	53 55N.	0 24 E.	4 30
Hyneago	Am.	Bahama	Atl. Ocean	21 07N.	73 01W	
I						
lo	Af.	Japon	S. Sea	36 00N.	139 40 E.	
Jaffanapatan	Af.	I. Ceylon	Ind. Ocean	9 47N.	80 55 E.	
Jago	Af.	C. Verd	Atl. Ocean	15 07N.	22 35W	
{ Weſt end				18 45N.	78 00W	
Port Royal	Am.	W. Indies	Atl. Ocean	17 40N	75 52W	
Eaſt end				17 58N.	76 05W	
nes Town	Am.	Virginia	B. Cheſapeak	37 30N.	76 00W	
Janeiro	Am.	Braſil	Atl. Ocean	23 00 S.	41 08W	
an Iſles	Af.		S. Sea	{ 40 40N.	141 25 E.	
				31 45N.	126 10 E.	
{ C. Delo, W. pt.				6 50 S.	105 15 E.	
	Af.	Siam	Ind. Ocean	{ 7 00 S.		
Eaſt limit				8 30 S.	115 55 E.	
Point	Eu.	Nov. Zem	N. Ocean	77 40N.	69 10 E.	
Sound	Eu.	Greenlnd.	N. Ocean	78 13N.	12 00 E.	
Jerſey	Eu.	England	Engl. Chan.	49 07N.	2 26W	
uſalem	Af.	Paleſtine	Inland	31 50N.	35 25 E.	
Illay, S. pt.	Eu.	Scotland	Weſt Ocean	55 39N.	6 20W	
Indus	Af.	India	Ind. Ocean	25 50N.	66 33E.	
erneſs	Eu.	Scotland	Germ. Oce.	57 33N.	4 02W	
oanna	Af.	Zangueb.	Ind. Ocean	12 05 S.	45 45 E	
dah	Af.	Arabia	Red Sea	22 00N.	39 27 E.	
St. John	Am.	Newfland	W. Ocean	50 25N.	52 45W	
St. John	Af.	Maiumbo	Eth. Ocean	1 17N.	9 34 E.	
t St. Johns	Am.	Newfland	Atl. Ocean	48 04N.	50 05W	
John { E. pt.	Am.	Canada	B. St. Laurence	46 36N.	60 00W	
W. pt.				47 35N.	62 05W	
t. John de Nova	Af.	Madagaſ.	Ind. Ocean	17 00 S.	44 02 E.	
John de Luz	Eu.	France	B Biſcay	43 10N.	1 38W	3 30
e Jones	Am.	New Brit.	Hudſ. Bay	55 15N.	79 00W	
pa	Af.	Syria	Levant	32 45N	36 00 E.	

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
Jones's Sound	Am.	Groenlnd.	Baffin's Bay	71 07N.	91 30W	
Ipſwich	Eu.	England	Germ. Oce.	52 14N.	1 00E.	
Iſpahan	Aſ.	Perſia	R. Zenderu	32 25N.	52 55E.	
I. Juan fernandes	Am.	Chili	S. Sea	34 10 S.	79 35W	
Por. St. Julian	Am.	Patagonia	S. Atl. Ocean	48 51 S.	65 10W	
I. Ivica	Eu.	Spain	Medit. Sea	38 54N	1 15E.	
K						
Kalmer	Eu.	Sweden	Baltic Sea	56 40N.	17 25E.	
Kambaya	Aſ.	India	Ind. Ocean	23 36N.	72 50E.	
Kam-chatka Lower	Aſ.	Siberia	South Sea	56 11N.	159 25E.	
Kam-chatka Upper				54 48N.	157 25E.	
I. Karaghinſkoy	Aſ.	Siberia	S. Sea	58 00N.	162 10W	
I. St. Katherines	Am.	Braſil	Atl. Ocean	27 45 S.	47 58W	
Keco	Aſ.	Tonquin	Ind. Ocean	21 55N.	106 10E.	
Kegor	Eu.	Moſcovy	N. Ocean	70 18N.	34 00E.	
R. Kennebeck	Am.	New Eng.	Atl. Ocean	44 00N.	69 45W	
Kentiſh knock, a ſand	Eu.	England	Germ. Oce.	51 42N.	1 45E.	oh. oom
I. St. Kilda	Eu.	Scotland	W. Ocean	57 44N.	8 18W	
I. Kilduin	Eu.	Lapland	N. Ocean	69 30N	31 20E.	7 30
Kinſale	Eu.	Ireland	Atl. Ocean	51 32N.	1 20W	4 30
Klip	Eu.	Greenlnd.	N. Ocean	80 10N.	12 22E.	
R. Kola	Eu.	Lapland	N. Ocean	69 20N.	35 30E.	
C. Kol	Eu.	Sweden	Sound	56 50N.	13 13E.	
Port Komol	Aſ.	Abyſſinia	Red Sea	22 30N.	36 17E.	
Komero Iſles	Aſ.	Zangueb.	Ind. Ocean	10 48 S. 13 10 S.	44 46E. 46 22E.	
R. Kowimia	Aſ.	Siberia	N. Ocean	70 40N	159 00E.	
L						
Ladrone, or Marian Iſles	Aſ.	———	S. Ocean	21 00N. 13 15N.	144 00E. 142 55E.	
C. Lagulias	Aſ.	Cafraria	Ind. Ocean	34 45 S.	21 40E.	
Lancaſter	Eu.	England	St. Geo. Ch.	54 42N	4 36W	
I. Lancerota	Aſ.	Canaries	Atl. Ocean	29 30N	12 20W	
Land's End	Eu.	England	St. Geo. Ch.	50 06N.	6 00W	7 30
Langeneſs	Eu.	Nov Zem	N. Ocean	74 40N	53 36E.	
I. Lambay	Eu.	Ireland	Iriſh Sea	53 24N.	7 30W	8 15
I. Lampadoſa	Aſ.	Tunis	Medit. Sea	35 32N.	12 45E.	
B. St. Lazarus	Am.	Patagon	S. Sea	48 42 S	73 35W	
C. Ledo	Aſ.	Angola	Atl. Ocean	9 24 S.	12 55E.	
Leith	Eu.	Scotland	Germ. Oce.	55 58N	2 59W	4 30
Leghorn	Eu.	Italy	Medit. Sea	43 33N.	10 25E.	
I. Lemnos	Aſ.	Natolia	Archipelago	40 02N.	25 36E.	
C. Lengua	Eu.	Turkey	Medit. Sea	40 44N.	19 36E.	
Leoſtaff	Eu.	England	Germ. Oce.	52 38N.	1 54E.	9 45
Lepanto	Eu.	Turkey	Medit. Sea	38 20N.	22 03E.	
I. Leſow	Eu.	Denmark	Sound	57 05N.	11 06E.	

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
everpool	Eu.	England	Iriſh Sea	53 22N.	2 30W	
. Lewes, N. pt.	Eu.	Scotland	Weſt. Ocean	58 35N.	6 37W	
iampo, or Ningpo	Af.	China	South Sea	30 00N.	120 30E	
ima	Am.	Peru	South Sea	12 20 S.	77 35W	
ime	Eu.	England	Eng. Chan.	50 45N.	3 15W	
imerick	Eu.	Ireland	R. Shannon	52 22N.	9 48W	
. Limoſa	Eu.	Italy	Med. Sea	36 08N.	13 01 E.	
. Lipari	Eu.	Italy	Medit. Sea	38 35N.	15 31 E.	
. Liqueo	Af.	Japan	South Sea	28 00N.	127 30 E	
iſbon	Eu.	Portugal	R. Tagus	38 42N.	8 52W	2h. 15m.
iſbon Rock	Eu.	Portugal	W. Ocean	38 42N.	9 25W	
. Liſſa	Eu.	Dalmatia	Adriat. Sea	42 56N.	18 32 E.	
izard	Eu.	England	Engl. Chan.	49 57N.	5 14W	7 30
s. Loffout S.W. end	Eu.	Norway	N. Ocean	68 15N.	10 20 E.	
N.E. end				69 00N.	12 00 E.	
. Loire, Ent.	Eu.	France	B. Biſcay	47 07N.	2 05W	3 00
ondon	Eu.	England	R. Thames	51 32N.	0 00	3 00
New London	Am.	New Eng.	W. Ocean	41 50N.	72 14W	
ondonderry	Eu.	Ireland	Weſt. Ocean	55 01N.	7 31W	
ong Iſle	Am.	New Eng.	W. Ocean	41 00N.	71 59W 74 20W	
. Longo	Eu.	Dalmatia	Adriat. Sea	43 45N.	17 58E	
ongſand Head	Eu.	England	Germ. Oce.	51 47N.	1 41E.	
ookout Point	Eu.	Greenlnd.	N. Ocean	76 40N.	16 25 E	
. Lopas	Af.	Loango	Atl. Ocean	0 47 S.	8 30 E.	
. St. Louis	Am.	Louiſiana	G. Mexico	28 50N.	97 08W	
ouiſbourg	Am.	C. Breton	B. St. Lawr.	46 50N.	61 30W	
ubec	Eu.	Germany	Balt. Sea	54 00N.	11 40 E.	
. St. Lucas	Am.	California	South Sea	23 15N.	111 35W	
. Lucia	Af.	Caffers	Ind. Ocean	27 52 S.	33 28 E.	
. St. Lucia	Af.	C. deVerd	Atl. Ocean	17 25N.	24 05W	
. St. Lucia	Am.	Caribbe	Atl. Ocean	13 45N.	61 00W	
N. E. point				19 25N.	121 45 E.	
C. Bajador				18 50N.	120 25 E.	
Manila	Af.	Phil. Is.	South Sea	14 30N	120 30 E.	
S. W. point				13 30N.	119 35 E	
E. point				14 00N.	124 00 E.	
unden	Eu.	Sweden	Baltic Sea	55 42N.	13 25 E.	
Lundy	Eu.	England	St. Geo. Ch.	51 20N.	4 04W	5 15
upis's Head	Eu.	Ireland	W. Ocean	52 24N.	10 15W	
ynn	Eu.	England	Germ. Oce.	52 55N.	0 32 E.	6 00
M						
. Mabo	Af.	New Guinea	S. Ocean	0 40 S.	130 05 E.	
acao, or Makau	Af.	China	S. Sea	22 13N.	113 51 E.	
acaſſar	Af.	I. Celebes	S. Sea	4 40 S.	119 05 E.	
. Machian	Eu.	Spain	B. Biſcay	43 44N.	3 05W	

Names of Places	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Wat
				° '	° '	
I. Madagaſcar, C. St. Mary, S. pt.	Af.	——	Ind. Ocean	25 24 S	45 53 E.	
B.S. Auguſtine				23 15 S	44 25 E.	
Terra de Gada				19 36 S.	44 46 E.	
C. St. Andrew				15 46 S.	45 22 E.	
C. St. Sebaſtian				12 30 S.	49 13 E.	
C. de Ambre, N. pt				12 15 S.	50 15 E.	
B. d'Antongil				16 00 S.	49 40 E.	
Antavare				20 53 S.	47 48 E.	
Po. Dauphin				24 48 S.	48 06 E.	
I. Madeira, Funchal	Af.	Canaries	Atl. Ocean	32 38N.	16 51W	
W. end				32 25N.	17 21W	
Madrid	Eu.	Spain	R. Manzanares	40 25N.	03 39W	
Madura	Af.	India	Ind. Ocean	10 15N.	78 35 E.	
R. Maes, mouth	Eu.	Dutchlnd.	Germ. Oce.	52 06N.	3 50 E.	oh. 45
Str. Le Maire	Am.	Patagonia	Atl. Ocean	55 00 S.	62 10W	
Magadoxa	Af.	Zangueb.	Ind. Ocean	2 53N.	45 25 E.	
Str. Magellan, E. ent.	Am.	Patagonia	Atl. Ocean	52 50 S.	72 35W	
W. ent			S. Sea	52 36 S.	62 35W	
Magiſilan	Af.	India	Malab. Coa	12 10N.	74 14 E	
I. Maguana	Am.	Bahama I.	Atl. Ocean	22 36N.	72 25W	
P. Mahon, Iſl. Minorca	Eu.	Spain	Medit. Sea	39 45N.	4 19 E.	
Majorca, Iſl. Majorca	Eu.	Spain	Medit. Sea	39 45N.	2 25 E.	
C. Mala	Eu.	Turkey	Archipelago	37 20N.	24 07 E	
Malacca	Af.	India	Str. Malacca	2 12N.	102 10 E.	
Malaga	Eu.	Spain	Medit. Sea	36 43N.	4 02W	
Is. Maldive, N. end	Af.	India	Ind. Ocean	7 20N.	73 03 E.	
S. end				0 20 S	76 10 E.	
Maleſtroom Whirlpool	Eu.	Norway	W. Ocean	68 08N.	10 40 E.	
I. Malique	Af.	Maldive I	Ind. Ocean	7 45N.	72 40 E	
St. Maloes	Eu.	France	Eng. Chan.	48 39N.	2 05W	6 o
I. Malta	Eu.	Italy	Medit. Sea	35 54N.	14 34 E.	
I. Man, W. end	Eu.	England	Iriſh Sea	53 45N	5 00W	9 o
Mangalor	Af.	India	Ind. Ocean	13 02N.	75 10 E.	
Str. Manila	Af.	I. Luconia	South Sea	14 35N.	124 00 E.	
I. Mansfield, N. pt.	Am.	New Brit	Hud. Bay	62 27N.	80 30W	
I. Manſia	Af.	Zangueb.	Ind. Ocean	8 36 S.	40 40 E.	
I. Mardou	Eu.	Norway	Sound	58 14N.	8 55 E.	
I. Margarita	Am.	Terra Fir.	Atl. Ocean	11 15N.	63 35W	
R. Maragnon	Am.	Braſil	Atl. Ocean	1 48 S	44 17W	
Margate	Eu.	England	Eng. Chan.	51 29N.	1 10 E.	11 15
C. St. Maria	Eu.	Portugal	Atl. Ocean	36 45N.	7 45W	
C. St. Maria, or Lucia	Eu.	Italy	Medit. Sea	40 04N.	18 31 E.	
Marian, or Ladrone Iſles, N. lim.	Af.	——	S. Ocean	21 00N.	144 00 E.	
S. lim.				13 15N.	142 55 E.	
I. St. Maries	Eu.	Azores	Atl. Ocean	37 00N.	22 56W	

St. Ma

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° '	° '	
St. Maries	Eu.	I. Scilly	Eng. Chan.	49 57N.	6 45W	
I. Marigallante	Am.	W. Indies	Atl. Ocean	16 00N.	61 10W	
I. Maritimo, Sicily	Eu.	Italy	Medit. Sea	38 04N.	12 33E.	
C. Martelo	Eu.	Turkey	Med. Sea	38 00N.	26 00E.	
St. Martha	Am.	Ter.Firm.	Atl. Ocean	11 20N.	73 40W	
. St. Martin	Am.	W. Indies	Atl. Ocean	18 06N.	62 30W	
C. St. Martin	Af.	Caffers	Atl. Ocean	32 08 S.	18 58E.	
C. St. Martin	Eu.	Spain	Medit. Sea	38 44N.	0 25E.	
. Martinique, Fo. Royal	Am.	W. Indies	Atl. Ocean	14 33N.	60 54W	
Marſeilles	Eu.	France	Mediter. Sea	43 18N.	5 27E.	
C. St. Mary	Am.	Newfland	Atl. Ocean	46 52N.	52 15W	
C. St. Mary	Am.	Braſil	Atl. Ocean	34 52 S.	52 55W	
C. St. Mary	Af.	Natolia	Archipelago	37 46N.	27 21E.	
C. St. Mary	Eu.	Spain	N. Atl. Oce.	36 46N.	7 49W	
. Virgin Mary	Am.	Patagonia	S. Atl. Oce.	52 21 S.	67 29W	
Maſcarenhas	Af.	Zangueb.	Ind. Ocean	3 30 S.	57 25E.	
. Maſcarin	Am.	Peru	S. Ocean	1 20 S.	88 50W	
Maſcat	Af.	Arabia	Ind. Ocean	23 10N	57 40E.	
Maſterland	Eu.	Sweden	Sound	57 58N	12 00E.	
Maſulipatan	Af.	India	B. Bengal	16 28N.	81 40E.	
. Matapan	Eu.	Turkey	Archipelago	36 25N.	22 40E.	
. Matbare	Af.	Japan	S. Ocean	26 30N.	137 00E.	
. St. Mathews	Af.	Guinea	Eth. Ocean	1 23 S	6 11W	
. Mauritius	Af.	Madagaſ.	Ind. Ocean	20 15 S.	58 10E.	
. May	Af.	CapeVerd	Atl. Ocean	15 19N.	21 53W	
. May	Am.	Penſilvan.	Atl. Ocean	39 15N	74 43W	
. Mayetta	Af.	Madagaſ.	Ind. Ocean	12 53 S	46 10E.	
Mecca	Af.	Arabia	Red Sea	21 40N.	41 00E.	
Medina	Af.	Arabia	Red Sea	24 58N.	39 53E	
. Melada	Eu.	Dalmatia	Adriat. Sea	42 40N	19 34E.	
Melinde	Af.	Zangueb.	Ind. Ocean	3 07 S	39 40E.	
. Melo	Eu.	Turkey	Archipelago	36 41N	25 05E.	
Memel	Eu.	Courland	Bal. Sea	55 48N.	22 23E.	
Memiſſan	Eu.	France	B. Biſcay	44 20N.	1 23W	3h. 30m.
. Menado	Af.	I. Celebes	S. Sea	1 36N.	122 25E.	
. Mendozin	Am.	California	S. Sea	41 20N.	130 15W	
. Meraparvous	Am.	Bahama	Atl. Ocean	21 58N.	74 13W	
Meſſina	Eu.	I. Sicily	Medit. Sea	38 21N.	16 21E.	
. Meſurato	Af.	Tripoli	Medit. Sea	32 18N.	16 36E.	
Me-ylene C. Sigre	Af.	Natolia	Archipelago	39 21N.	26 08E.	
Metylene				39 11N.	26 47E.	
Po.Olivier				39 00N.	26 50E.	
Meun	Eu.	Denmark	Balt. Sea	55 00N.	13 15E.	
Mexico	Am.	Mexico	Inland	20 00N.	103 35W	
St. Michael	Eu.	Azores	Atl. Ocean	38 13N	22 50W	
Middleburg	Eu.	Dutchlnd.	Germ. Oce.	51 37N.	3 58E.	
Milford	Eu.	Wales	St. Geo. Ch	51 45N.	5 15W	5 15
Milo, I. Milo	Af.	Turkey	Archipelago	36 41N	25 05E.	
Mills's Iſles	Am.	N. Main	Hudſ. Bay	64 36N	80 30W	

I. Min-

Names of Places	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Wa
				° ′	° ′	
I. Mindanao N. point	Aſ.	Spice Iſles	South Sea	9 40N.	124 25 E.	
I. Mindanao S. E. pt. C. Saint Auguſtine				6 40N.	126 25 E.	
I. Mindanao S.W.pt. Caldera				7 00N.	121 25 E.	
I. Mindanao S. point				3 50N.	124 43 E.	
I. Mindora	Aſ.	Philip. Is.	South Sea	13 00N.	119 37 E.	
I. Minorca N.W.pt.	Eu.	Spain	Medit. Sea	39 58N.	3 54 E	
I. Minorca S. E. pt.				40 24N.	4 18 E.	
I. Miſcou	Am.	Nov.Scot.	G. St. Lawr.	47 45N.	62 09W	
C. Miſerata	Af.	Guiney	Atl. Ocean	6 25N.	9 35W	
Miſſen Head	Eu.	Ireland	Atl. Ocean	51 16N.	11 30W	
R. Miſſiſſipi, mouth	Am.	Louiſiana	G. Mexico	29 00N.	89 17W	
Mocha	Aſ.	Arabia	Red Sea	13 45N.	44 04 E	
Modon	Eu.	Turkey	Medit. Sea	36 55N.	21 03 E.	
I. Mohilla	Af.	Zangueb.	Ind. Ocean	11 55 S.	45 00 E.	
I. Monſerat	Am.	W. Indies	Atl. Ocean	16 37N.	62 13W	
Mont Real	Am.	Canada	R. Canada	45 52N.	73 11W	
I. Monte Chriſto	Eu.	Italy	Medit. Sea	42 17N.	10 28 E.	
C. Monte Sancto	Eu.	Turkey	Archipelago	40 27N.	24 39 E.	
Mount St. Michael	Eu.	France	Engl. Chan.	48 39N.	1 35W	
I. Morgo	Aſ.	Natolia	Archipelago	36 55N.	26 30 E.	
Morlaix	Eu.	France	Eng. Chan.	48 30N.	3 50W	
Mort Point	Eu.	England	St. Geo. Ch.	51 12N.	4 40W	
Moſambique	Af.	Zangueb.	Ind. Ocean	15 00 S.	41 40 E.	
Moſcow	Eu.	Ruſſia	R. Moſcow	55 36N.	40 25 E.	
Moſquitos Bank	Am.	Mexico	Atl. Ocean	14 45N.	80 05W	
C. Mount	Af.	Guinea	Atl. Ocean	7 12N.	10 44W	
Mounts Bay	Eu.	England	Engl. Chan.	50 05N.	5 45W	4h. 3
Mouſe River	Am.	New Wls	Hudſ. Bay	51 25N.	83 15W	
C. Muſaldon	Aſ.	Arabia	Perſ. Gulf	26 04N.	55 22 E.	
N						
C. Nabo	Aſ.	Japan	S. Ocean	40 35N.	141 25 E.	
Nangaſack	Aſ.	Japan	South Sea	32 45N.	128 50 E.	
Nankin	Aſ.	China	South Sea	32 07N.	118 35 E.	
Nantes	Eu.	France	B. Biſcay	47 13N.	1 29W	3 0
Nantuck Iſle	Am.	New Eng.	W. Ocean	41 34N.	69 40W	
Naples	Eu.	Italy	Medit. Sea	40 51N.	14 45 E.	
Narbonne	Eu.	France	Medit. Sea	43 11N.	3 05 E.	
Narſinga	Aſ.	India	B. Bengal	18 05N.	85 20 E.	
Narva	Eu.	Livonia	G. Finland	59 08N.	29 18 E.	
I. Naſſau	Aſ.	Siam	Ind. Ocean	3 00 S.	100 25 E.	
C. Naſſau	Am.	Ter.Firm.	Atl. Ocean	7 53N.	58 07W	
Naſſau Str.	Eu.	Ruſſia	N. Ocean	69 55N.	57 30 E.	
B. Natal	Af.	Caffers	Ind. Ocean	29 25 S.	33 10 E	
I. Naxos	Eu.	Turkey	Archipelago	37 06N.	25 58 E.	

Ne

ames of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
aze	Eu.	Norway	W. Ocean	57 50N.	7 32 E.	11h. 15m.
edles	Eu.	England	Eng. Chan.	50 41N.	1 48W	9 45
Negrailles	Af.	Pegu	B. Bengal	16 20N.	94 15 E.	
Negro	Af.	Caffres	Atl. Ocean	16 30 S.	11 30 E.	
Negro	Af.	Barbary	Medit. Sea	37 17N.	9 09 E.	
gropont	Eu.	Turkey	Archipelago	38 30N.	24 05 E.	
rt Nelſon	Am.	New Wls.	Hudſ. Bay	57 07N	94 15W	
Nevis	Am.	Carib. Is.	Atl. Ocean	16 55N.	62 42W	
wcaſtle	Eu.	England	Germ.Ocean	55 03N.	1 28W	5 15
Nicaragua	Am.	NewSpain	Atl. Ocean	11 40N.	82 47W	
ce	Eu.	Italy	Medit. Sea	43 42N.	7 22 E.	
Nicobar	Af.	Siam	B. Bengal	7 22N.	94 40 E	
St. Nicholas	Af.	C. Verd	Atl. Ocean	17 05N.	23 28W	
cotera	Eu.	Italy	Medit. Sea	38 33N.	16 30 E.	
euport	Eu.	Flanders	Germ.Ocean	51 08N.	2 50E.	12 00
nhay	Af.	China	South Sea	37 10N.	122 25 E.	
gpo, or Liampo	Af.	China	S. Sea	30 00N.	120 50 E.	
Nio	Eu.	Turkey	Archipelago	36 48N.	26 02 E.	
Noel	Af.	India	Ind. Ocean	10 30 S.	105 25 E.	
de Non	Af.	Barbary	Atl. Ocean	28 04N.	10 32W	
mbre de dios	Am.	Ter. Fir.	Carib. Sea	9 43N.	78 35W	
re	Eu.	England	R. Thames	51 28N.	0 48 E.	0 00
North	Am.	Ter.Firm.	Atl. Ocean	1 45N.	49 00W	
Cape, I. Maggoroe	Eu.	Lapland	N. Ocean	71 27N.	26 30 E.	3 00
rth Point	Eu.	Norway	N. Ocean	62 15N.	6 15 E.	
Nottingham, E. pt.	Am.	New Brit.	Hudſ. Str.	63 33N.	78 20W	
O						
zakow	Eu.	Turkey	Black Sea	45 12N.	34 40 E.	
eland S. end N. end	Eu.	Sweden	Balt. Sea	56 15N. 57 23N.	18 35E. 17 36E.	
head of Kingſale	Eu.	Ireland	Atl. Ocean	51 35N.	8 58W	
leron	Eu.	France	B. Biſcay	45 51N.	1 25W	
inde	Am.	Braſil	S.Atl. Ocean	8 13 S.	35 05W	
va	Eu.	Germany	Balt. Sea	54 20N.	18 30 E.	
lone	Eu.	France	B. Biſcay	46 32N.	1 36W	3 45
eglia	Eu.	Italy	Medit. Sea	43 57N.	7 52 E	
orto	Eu.	Portugal	Atl. Ocean	40 53N.	8 35W	
an	Af.	Barbary	Medit. Sea	35 45N.	0 00W	
Orange	Am.	Ter.Firm.	Atl. Ocean	4 27N.	50 50W	
bitello	Eu.	Italy	Medit. Sea	42 30N.	12 00 E	
rchillo	Am.	Ter.Firm.	Carib. Sea	11 32N.	65 25W	
fordneſs	Eu.	England	Germ. Oce.	52 17N.	1 11 E.	9 45
ney Iſles, imits	Eu.	Scotland	W. Ocean	59 24N. 58 44N.	3 23W 2 11W	3 00
w Orleans	Am.	Louiſiana	R. Miſſiſſipi	30 00N.	90 00W	
rmus	Af.	Perſia	G. Perſia	27 30N.	55 17 E.	
el Oro, or Olerada	Af.	Negrolnd.	Atl. Ocean	23 30N.	14 31W	
Oronoque	Am.	Ter. Fir.	Atl. Ocean	08 08N.	59 50W	

C. Oro-

Names of Places.	Con.	Countries.	Coaſt.	Latitude.	Longitud.	H. Wat
				° '	° '	
C. Oropeſo	Eu.	Spain	Medit. Sea	40 20N.	0 49 E	
C. Ortegal	Eu.	Spain	B. Biſcay	44 07N.	8 00W	
Ortona	Eu.	Italy	Medit. Sea	42 19N.	14 37 E.	
I. Oruba	Am.	Ter. Firm.	Carib. Sea	12 03N	69 03W	
Oſtend	Eu.	Flanders	Germ. Oce.	51 14N.	3 00 E.	12h. oc
C. Otranto	Eu.	Italy	Medit. Sea	40 23N.	17 41 E.	
Ozaca	Aſ.	Japon	South Sea	35 10N.	134 05 E.	
P						
C. Padron	Af.	Congo	Atl. Ocean	6 00 S	11 40 E.	
Paita	Am.	Peru	South Sea	5 20 S.	80 35W	
C. Paillouri	Eu.	Turkey	Archipelago	39 59N.	24 03 E.	
Palermo, I. Sicily	Eu.	Italy	Medit. Sea	38 10N.	13 43 E.	
Paliakate	Aſ.	India	B. Bengal	13 40N.	80 50 E.	
I. Palma	Af.	Canaries	Atl. Ocean	28 35N.	17 30W	
I. Palmaria	Eu.	Italy	Medit. Sea	41 00N	13 03 E.	
C. Palmiras	Aſ.	India	B. Bengal	20 40N.	87 35 E.	
C. Palmas	Af.	Guiney	Atl. Ocean	4 26N.	5 56W	
Panama	Am.	Mexico	S. Ocean	8 45N.	79 55W	
I. Panaria	Eu.	Italy	Medit. Sea	38 40N.	15 41 E.	
Panorma	Eu.	Turkey	Medit. Sea	40 05N.	21 40 E.	
I. Pantalaria	Eu.	Italy	Medit. Sea	36 55N	12 31 E.	
Panuco	Am.	Mexico	G. Mexico	24 02N	100 13W	
R. Paraiba	Am.	Braſil	Atl. Ocean	21 26 S.	39 50W	
Paris	Eu.	France	R. Seine	48 50N.	2 25 E.	
C. Paſſero	Eu.	I. Sicily	Medit. Sea	36 35N.	15 22 E	
C. Patam	Aſ.	Malacca	Indian Oce.	7 27N.	101 20 E.	
I. Patmos	Aſ.	Natolia	Archipelago	37 22N	26 48 E.	
R. Pattahan'	Aſ.	I. Sumatra	Str. Malaca	0 28N	102 25 E.	
C. Paul	Eu.	Spain	Medit. Sea	37 50N.	0 15W	
I. St. Paul	Am.	Newf land	B. St. Lawr.	47 15N.	57 49W	
I. St. Paul	Af.	———	Ind. Ocean	38 20 S.	75 25 E.	
St. Paul de Leon	Eu.	France	Eng. Chan.	48 41N.	3 55W	4 oc
I. Paxeros	Am.	California	Pac. Ocean	30 18N.	120 45W	
I. Pearl, or Serana	Am.	W. Indies	Atl. Ocean	14 55N.	79 00W	
Pegu	Aſ.	India	B. Bengal	17 00N.	96 58 E.	
Pekin	Aſ.	China	Inland	39 54N.	116 41 E.	
I. Pelugoſa	Eu.	Italy	Adriat. Sea	42 20N.	18 32 E.	
I. Pemba	Af.	Zanguebar	Ind. Ocean	5 38 S.	40 09 E	
C. Pembroke	Am.	New Wls.	Hudſ. Bay	63 12N.	82 54 W	
I. Pengwin	Am.	Newf Ind.	Atl. Ocean	50 03N.	50 32W	
Penmark	Eu.	France	B. Biſcay	47 50N.	4 20W	
R. Penobſcut	Am.	New Eng.	Atl. Ocean	44 40N.	68 52W	
I. Pepys, or Penguin	Am.	Patagonia	S. Atl. Ocean	48 00 S.	64 50W	
Pernambuco	Am.	Braſil	S. Atl. Ocean	8 30 S.	35 07W	
Petapoli	Aſ.	India	B. Bengal	16 14N.	81 10 E	
Peterſbourg	Eu.	Ruſſia	Balt. Sea	60 00N.	30 25 E.	
C. Petra	Aſ.	Natolia	Archipelago	37 02N.	27 38 E	
Peverel Point	Eu.	England	Eng. Chan.	50 34N.	1 22W	
Philadelphia	Am.	Penſilvan.	R. Delawar	40 50N.	74 00W	

ames of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
t. Philip	Af.	Benguela	Atl. Ocean	12 22 S.	13 20 E.	
. Pianoſa	Eu.	Italy	Medit. Sea	42 46N.	10 34 E.	
. Pico	Eu.	Azores	Atl. Ocean	38 35N	26 20W	
. Pinas	Eu.	Spain	B. Biſcay	43 51N.	6 14W	
Io. Pintados, or St. Martin	Am.	California	S. Ocean	27 30N.	117 15W	
iſcadore Iſles	Af.	China	S. Sea	23 30N.	119 25E.	
lacentia	Am.	Newfland	Atl. Ocean	47 36N.	51 46W	
. Plata	Am.	Magellan	Atl. Ocean	36 00 S.	57 40W	
. Platewrack	Am.	Bahama I.	Atl. Ocean	20 04N	68 37W	
lymouth	Eu.	England	Engl. Chan.	50 26N.	4 27W	6h. 00m.
olicaſtro	Eu.	Italy	Medit. Sea	40 18N.	15 45 E.	
. Polſapate	Af.	Cambaya	Ind. Ocean	9 45N.	109 55 E.	
Poma	Eu.	Dalmatia	Adriat. Sea	42 57N.	18 14 E.	
ndicherry	Af.	India	B. Bengal	11 54N.	80 17 E	
ontorſon	Eu.	France	Engl. Chan	48 33N.	1 27W	
Ponza	Eu.	Italy	Medit. Sea	40 53N.	13 09 E.	
ol	Eu.	England	Engl. Chan.	51 00N.	1 50W	
rta Port	Eu.	Portugal	Atl. Ocean	40 53N.	8 35W	
rt Mahon	Eu.	Spain	Medit. Sea	39 45N.	4 19 E.	
rtland	Eu.	England	Eng. Chan.	50 30N.	2 48W	8 15
rt l'Orient	Eu.	France	Eng. Chan.	47 45N.	3 18W	
rto Bello	Am.	NewSpain	Carib. Sea	9 33N.	79 45W	
Porto Rico E. pt.				18 30N.	65 35W	
Porto Rico Porto Rico	Am.	Antilles	Atl. Ocean	18 25N.	66 05W	
Porto Rico W. pt.				18 30N.	67 15W	
Porto ſancto	Af.	Canaries	Atl. Ocean	33 07N.	15 53W	
rtſall	Eu.	France	Eng. Chan.	48 36N.	4 43W	
rtſmouth	Eu.	England	Engl. Chan.	50 49N.	0 46W	0 00
aken	Af.	Coch. Chi.	Ind. Ocean	17 15N.	106 15 E.	
enau	Eu.	Livonia	Baltic Sea	58 26N.	24 58 E.	
Princes	Af.	Guiney	Atl. Ocean	1 47N.	6 39 E.	
. Prior	Eu.	Spain	Atl. Ocean	43 53N.	8 22W	
Providence	Am.	Bahama	Atl. Ocean	24 51N.	77 01W	
. Providence, St. Catherine	Am.	Mexico	Atl. Ocean	13 26N.	80 42W	
Puli condor	Af.	Cambaya	Ind. Ocean	8 34N.	107 35 E.	
Q						
aqua, or Ivory Coaſt	Af.	Guinea	Eth. Sea	5 00N.	4 00W	
ebeck	Am.	Canada	R. Canada	46 55N.	69 48W	6 00
eda	Af.	India	B. Bengal	6 15N.	100 12 E.	
Quelpert	Af.	Korea	S. Sea	33 32N.	128 04 E	
iloa	Af.	Zangueb.	Ind. Ocean	9 30 S	39 09 E.	
imper	Eu.	France	B. Biſcay	48 00N.	4 06W	
inam	Af.	Coch. Chi	Ind. Ocean	12 52N.	109 10 E.	

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Wate
				° ′	° ′	
Quiraba Iſles	Aſ.	Zangueb.	Ind. Ocean	11 00N.	41 39E.	
Quito	Am.	Peru	Inland	0 13 S.	77 50W	
R						
C. Race	Am.	Newfland	Atl. Ocean	46 50N.	50 50W	
Raguſa	Eu.	Dalmatia	Medit. Sea	42 45N.	20 00 E.	
Rajapour	Aſ.	India	Ind. Ocean	17 19N.	73 50 E.	
Ramſgate	Eu.	England	Downs	51 20N.	1 22E.	
Ramhead	Eu.	England	Eng. Chan.	50 14N.	4 35W	
C. Raſalgate	Aſ.	Arabia	Ind. Ocean	22 46N.	58 48 E.	
Ravenna	Eu.	Italy	Medit. Sea	44 26N.	12 21 E.	
C. Ray	Am.	Newfland	Atl. Ocean	47 37N.	56 50W	
I. Ree	Eu.	France	B. Biſcay	46 08N.	1 28W	3h. 00
Regio	Eu.	Italy	Mediterran.	38 22N.	16 37 E.	
Is. Reſolution, E. limit	Am.	N. Main	Hudſ. Str.	61 36N.	64 38W	
Revel	Eu.	Livonia	Balt. Sea	59 22N.	25 33 E.	
Rhodes I. Rhodes, N end	Aſ.	Natolia	Archipelago	36 27N.	28 36 E.	
C. Tranquil, S. end				35 55N.	28 23 E.	
Riga	Eu.	Livonia	Baltic Sea	56 55N.	24 51 E.	
Rip raps, a ſand	Eu.	England	Str. Dover	51 53N.	1 25 E.	
Robin Hood's Bay	Eu.	England	Germ. Oce.	54 25N.	0 08W	3 00
I. Rocca	Am.	Ter.Firm.	Atl. Ocean	11 21N.	66 17W	
Rochefort	Eu.	France	B. Biſcay	46 00N.	1 00W	
Rochel	Eu.	France	B. Biſcay	46 10N.	1 11W	3 45
Rocheſter	Eu.	England	R. Medway	51 26N.	0 30 E.	0 45
I. Rodrigue	Aſ.	Madagaſ.	Ind. Ocean	19 45 S.	63 45 E.	
C. Romain	Am.	Ter.Firm.	Atl. Ocean	11 40N.	69 05W	
Rome	Eu.	Italy	Medit. Sea	41 54N.	12 45E	
I. Roncadore	Am.	Mexico	Atl. Ocean	13 30N.	78 53W	
Rood Bay	Eu.	Greenlnd.	N. Ocean	79 53N.	14 00 E.	
C. Roque	Am.	Braſil	Atl. Ocean	5 00 S.	35 43W	
I. Roquepiz	Aſ.	Madagaſ.	Ind. Ocean	9 51 S.	64 30 E	
G. Roſes	Eu.	Spain	Medit. Sea	42 10N.	3 18 E	
Roſtock	Fu.	Germany	Balt. Sea	54 10N.	12 50 E	
I. Rotterdam	Aſ.	———	S. Sea	20 05 S.	179 30W	
Rotterdam	Eu.	Dutchlnd.	Germ. Oce.	51 56N.	4 55 E.	3 00
Rouen	Eu.	France	R Seine	49 27N.	1 10 E.	3 45
C. Roxant	Eu.	Portugal	Atl. Ocean	38 42N.	9 35W	
C. Roxo	Aſ.	Negroind.	Atl. Ocean	11 42N.	14 33W	
Po. Royal	Am.	I. Jamaica	Carib. Sea	17 40N.	75 52W	
C. Rozier	Am.	Nov.Scot.	G. St. Laur.	49 00N	61 40W	
I. Rugen	Eu.	Germany	Balt. Sea	54 32N.	14 30 E	
I. Rum key, or Samana	Am.	Bahama	Atl. Ocean	23 00N.	74 20W	
R. Rupert	Am	New Brit.	Hudſ. Bay	51 45N.	78 40W	
C. Ruſato	Aſ.	Barca	Medit. Sea	32 53N.	20 41 E	

ames of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
uſt Iſles	Eu.	Norway	N. Sea	67 40N.	10 25 E.	
ye	Eu.	England	Eng. Chan.	51 03N.	0 45 E.	11h. 15m
S						
. Sable	Am.	Nov.Scot.	Atl. Ocean	43 56N.	66 25W	
. Sable	Am.	Nov.Scot.	Atl. Ocean	44 15N.	59 00W	
affia	Af.	Barbary	Atl. Ocean	32 30N.	8 50W	
. Safanjal bahr.	Af.	Egypt	Red Sea	27 05N.	34 40 E.	
. Saldanna	Af.	Caffers	Atl. Ocean	32 35 S	19 30 E.	
. Sal	Af.	C. Verde	Atl. Ocean	16 55N.	21 41W	
alerno	Eu.	Italy	Medit. Sea	40 39N.	14 48 E.	
Salini, Lipari Is.	Eu.	Italy	Medit. Sea	38 39N.	15 24 E.	
. Saliſbury	Am.	N. Main	Hudſ. Bay	63 35N	77 00W	
allee	Af.	Barbary	Atl. Ocean	33 58N.	6 20W	
alomon Iſles	Af.	——	S. Sea	5 50 S. 11 15 S.	171 05W 178 35W	
alonechi	Eu.	Turkey	Archipelago	40 41N	23 13 E.	
Salvages	Af.	Canaries	N. Atl. Oce	30 14N.	14 59W	
Samos	Af.	Natolia	Archipelago	37 46N.	27 13 E.	
andwich	Eu.	England	Downs	51 20N.	1 20E	
Sanguin	Af.	Philip. Is.	S. Sea	3 50N.	122 30 E.	
Sanien	Eu.	Norway	N. Ocean	69 30N	14 30 E.	
anta Cruz	Af.	Barbary	Atl. Ocean	30 30N.	9 35W	
N. limit	Eu.	Italy	Medit. Sea	41 15N.	9 31 E.	
S. pt. C. Tavolaro				38 54N.	9 15 E.	
Cagliari				39 25N.	9 38 E.	
Oriſtagni				39 53N.	9 01 E	
arena	Am.	Chili	South Sea	29 40 S.	71 15W	
canderoon	Af.	Syria	Levant	36 35N.	36 25 E.	
carborough head	Eu.	England	Germ.Ocean	54 18N	00 00 E.	3 45
Scarpanto	Af.	Natolia	Archipelago	35 45N.	27 40 E	
caw	Eu.	Denmark	Sound	57 34N.	10 54 E.	
Schelling	Eu.	Dutchlnd.	Germ. Oce.	53 27N.	5 30 E.	
C. St. Nicholas	Af.	Natolia	Archipelago	38 38N.	26 12 E.	
Scio				38 24N.	26 29 E.	
C. Blanco				38 08N.	26 20 E	
cilly Iſles	Eu.	England	St. Geo. Ch.	50 00N.	6 45W	3 45
cots Settlement	Am.	Ter. Fir.	Carib. Sea	8 45N.	76 35W	
Sea	Eu.	Turkey	Archipelago	37 38N.	24 53 E	
eames	Eu.	France	B. Biſcay	48 00N.	4 51W	
Sebaldes	Am.	Patagonia	S.Atl. Ocean	50 53 S.	59 35W	
. Sebaſtian	Am.	California	South Sea	43 00N	126 00W	
. St. Sebaſtian	Af.	Madagaſ.	Ind. Ocean	12 30 S.	49 13 E.	
. Sebaſtian	Eu.	Spain	B. Biſcay	43 16N.	2 05W	
. Segura	Am.	Braſil	Atl. Ocean	16 57 S.	39 45W	
. Senegal	Af.	Negrolnd	Atl. Ocean	15 40N.	16 20W	10 30
Seranilha	Am.	W. Indies	Atl. Ocean	16 20N.	79 40W	
Seriga	Eu.	Turkey	Archipelago	36 09N.	23 24 E.	

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Wa
				° ′	° ′	
I. Sertes	Af.	Canaries	Atl. Ocean	32 35N.	16 20W	
R. Seſtos	Af.	Guinea	Atl. Ocean	5 48N.	8 13W	
Seven Capes	Af.	Barbary	Med. Sea	37 30N.	6 15W	
Seven Stones	Eu.	England	St. Geo. Ch.	50 10N.	6 40W	4h. 3
R. Severn, Ent.	Eu	England	St. Geo. Ch.	51 41N	3 05W	4 3
R. Seyn, Ent.	Eu.	France	Engl. Chan.	49 36N.	0 30 E	10 3
Seyn Head	Eu.	France	Eng. Chan.	49 44N.	0 34 E	
Sheerneſs	Eu.	England	R. Thames	51 25N.	00 50 E.	1 0
Siam	Af.	India	B. Siam	14 18N.	100 55 E.	
R. Siam, Ent.	Af.	India	B. Siam	13 15N.	100 47 E.	
Siara	Am.	Braſil	Atl. Ocean	3 18 S.	39 50W	
Iſl. Sicily, E. end, Meſſina	Eu.	Italy	Medit. Sea	38 10N.	15 58 E.	
Catanea				37 22N.	15 21 E.	
Syracuſe				37 04N.	15 31 E.	
S. end, C. Paſſaro				36 35N.	15 22 E.	
Alicata				37 11N.	14 07 E.	
W. end, C. Boeo				37 51N.	12 43 E.	
Palermo				38 10N.	13 43 E.	
Sierro Leona	Af.	Guiney	Atl. Ocean	8 30N.	12 07W	8 1
Sillabar Road	Af.	I. Sumatra	Ind. Ocean	4 00 S	102 50 E.	
Str. Sincapore	Af.	Malaca	Ind. Ocean	1 00N	104 30 E.	
R. Sinda, or Indus, mouth	Af.	India	Ind. Ocean	24 30N. 25 45N.	63 10 E. 62 40 E.	
Po. Shabak	Af.	Abyſſinia	Red Sea	18 58N.	38 24 E.	
Shark, or Sea-horſe pt.	Am.	New Wls	Hudſ. Bay	64 05N.	82 12W	
Sheilds	Eu.	England	Germ. Oce.	55 02N	1 20W	
Shelvock's Iſle	Am.	California	South Sea	23 15N.	117 35W	
Shillocks	Eu.	Ireland	Weſt. Ocean	51 30N.	11 55W	
I. Shetland, limits	Eu.	Scotland	Weſt. Ocean	60 47N. 59 54N.	0 10W 1 31W	3 c
Shoram	Eu.	England	Eng. Chan.	50 55N.	00 17 E.	9 4
I. Sky, N. pt. S. pt.	Eu.	Scotland	W. Ocean	57 50N. 57 15N	6 30W 6 16W	
Sleepers Iſles	Am.	New Brit	Hudſ. Bay	60 00N. 58 35N.	81 30W	
Sline Head	Eu.	Ireland	W. Ocean	53 20N	11 15W	
R. Slude	Am.	New Brit	Hud. Bay	53 24N	78 50W	
Sluyce	Eu.	Dutchlnd.	Germ. Oce.	51 19N.	3 50E.	
Smyrna	Af.	Natolia	Archipelago	38 28N.	27 25 E.	
I. Socatora	Af.	Anian	Ind. Ocean	12 15N.	52 55 E.	
C. Solomon	Eu.	I. Candia	Medit. Sea	34 57N.	27 06 E.	
R Somme	Eu.	France	Eng. Chan.	50 18N.	1 40 E.	11 0
Sound royal	Eu.	Iceland	N. Ocean	66 22N.	15 15W	
Southampton	Eu.	England	Eng. Chan.	50 55N	1 30W	0 0
C. Southampton	Am.	New Wls	Hudſ. Bay	61 54N	86 14W	
South Cape	Af.	Diemen'sLnd	S. Ocean	42 40 S.	130 05 E	
C. Spartivento	Eu.	Italy	Medit. Sea	37 50N.	16 41 E.	
C. Spartel	Af.	Barbary	Atl. Ocean.	35 42N.	5 47W	

Names of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
				° ′	° ′	
. Spigie	Aſ.	NewZeld.	S. Ocean	41 45 S.	162 50 E.	
. Spirito ſancto	Am.	Braſil	Atl. Ocean	20 24 S.	39 55 W	
purn	Eu.	England	Germ. Oce.	53 35 N.	0 30 E.	5h. 15m.
. Stampalia	Aſ.	Natolia	Archipelago	36 25 N.	26 55 E.	
. Stancho	Aſ.	Natolia	Archipelago	36 50 N.	27 30 E.	
tart pt.	Eu.	England	Engl. Chan.	50 09 N	2 45 W	6 45
States { CapeSt John	Am.	Patagonia	Atl. Ocean	54 45 S.	60 35 W	
CapeSt. Barthol.				55 08 S.	60 45 W	
tavenger	Eu.	Norway	W. Ocean	58 47 N.	6 45 E.	
tetin	Eu.	Germany	Balt. Sea	53 36 N.	15 25 E.	
. Stillo	Eu.	Italy	Medit. Sea	38 23 N.	17 07 E.	
ort Steven	Am.	Chili	South Sea	46 50 S.	82 36 W	
tockholm	Eu.	Sweden	Baltic Sea	59 20 N.	19 30 E.	
tockton	Eu.	England	Germ. Ocean	54 33 N.	1 15 W	5 15
raelſund	Eu.	Germany	Balt. Sea	54 23 N.	14 10 E	
ranford Bay	Eu.	Ireland	Iriſh Sea	54 23 N.	5 40 W	
Stromboli	Eu.	Italy	Medit. Sea	38 42 N.	15 48 E.	
ıez Town	Aſ.	Egypt	Red Sea	29 50 N.	33 27 E.	
ıkadana	Aſ.	I. Borneo	Ind. Ocean	1 00 S	110 40 E.	
Su- { NW.end	Aſ.	India	Ind. Ocean	5 15 N.	95 55 E.	
natra SE. end				5 07 S.	106 20 E.	
ınderland	Eu.	England	Germ. Oce.	54 55 N.	1 00 W	
r. Sunda	Aſ.	Siam	Ind. Ocean	6 10 S	105 35 E.	
ıranam	Am.	Ter. Firm.	Atl. Ocean	6 30 N.	55 30 W	
ırat	Aſ.	India	Ind. Ocean	21 10 N	72 25 E.	
Surroy	Eu.	Lapland	N. Ocean	71 00 N.	22 00 E.	
vaken	Aſ.	Abaſſin	Red Sea	19 30 N.	37 38 E	
vally Road	Aſ.	India	Arab. Sea	21 55 N	72 00 E.	
vanſey	Eu.	Wales	St. Geo. Ch.	51 40 N.	4 25 W	
veetnoſe	Eu.	Lapland	N. Ocean	68 08 N.	34 42 E.	
vin, a ſand	Eu.	England	Ent. Thames	51 37 N	1 12 E.	12 00
racuſe	Eu.	I. Scilly	Medit. Sea	37 04 N.	15 20 E.	
riam	Aſ.	Pegu	B. Bengal	16 00 N.	96 40 E.	
T						
adouſac Fort	Am.	Canada	R. Canada	48 00 N.	67 35 W	
Tamarica	Am.	Braſil	Atl. Ocean	7 56 S.	35 05 W	
amarin Town	Aſ.	I. Sokotra	Ind. Ocean	12 30 N.	53 14 E.	9 00
Tanaſſarin	Aſ.	Malacca	B. Bengal	12 00 N.	98 40 E.	
Tandoxima	Aſ.	Japan	S. Sea	30 30 N.	130 40 E.	
ingier	Aſ.	Barbary	Atl. Ocean	35 55 N.	5 45 W	
ırento	Eu.	Italy	Medit. Sea	40 43 N.	17 31 E.	
Tees, mouth	Eu.	England	Germ. Oce.	54 36 N.	0 52 W	3 00
goantepec	Am.	Mexico	South Sea	14 45 N.	96 23 W	
llichery	Aſ.	India	Mallab. coaſt	11 42 N.	75 30 E	
Telling	Eu.	Ireland	W. Ocean	54 40 N.	10 07 W	
Tenedos	Aſ.	Natolia	Archipelago	39 57 N.	26 14 E	
Teneriff	Aſ.	Canaries	Atl. Ocean	28 23 N	15 28 W	3 00

C. Tenes

Names of Places	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Wat
				° ′	° ′	
C. Tenes	Af.	Barbary	Medit. Sea	36 26N.	1 53 E	
I. Tercera	Eu.	Azores	Atl. Ocean	39 06N.	24 52W	
Tervere	Eu.	Dutchlnd.	Germ. Oce.	51 38N.	3 35 E.	oh. 45
Tetuan	Af.	Barbary	Medit. Sea	35 27N.	4 50W	
I. Texel	Eu.	Dutchlnd.	Germ. Oce.	53 10N.	4 59 E	7 3
C. St. Thadæus	Af.	Siberia	N. Ocean	62 10N.	175 05 E.	
R Thames, mouth	Eu.	England	Germ. Oce.	51 28N.	1 10 E	
C. St. Thomas	Af.	Caffres	Atl. Ocean	24 54 S.	15 25 E.	
I. St. Thomas	Af.	Guinea	Atl. Ocean	00 00	1 00 E.	
St. Thomas	Af.	India	B. Bengal	13 00N.	80 00 E	
C. Three Points	Am.	Ter. Firm.	Atl. Ocean	10 51N.	62 41W	
C. Three Points	Af.	Guinea	Atl. Ocean	4 48N.	1 21W	
I. Tidore	Af.	Maluc. Is.	Ind. Ocean	0 35N.	126 40 E.	
I. Timor { NE. pt. SW. pt	Af.	Maluc. Is.	Ind. Ocean	8 20 S. 10 10 S.	127 40 E. 123 55 E.	
Tinmouth	Eu.	England	Germ. Oce.	55 03N.	1 17W	3 0
I. Tino	Eu.	Turkey	Archipelago	37 33N.	25 43 E	
I. Tobago	Am.	Caribbe	Atl. Ocean	11 15N.	60 27W	
B. Todos ſanctos	Am.	Braſil	Atl. Ocean	13 05 S.	38 45W	
Tonquin	Af.	India	South Sea	20 50N.	105 55 E.	
Tonſberg	Eu.	Norway	Sound	58 50N.	10 05 E.	
Topſham	Eu.	England	Engl. Chan.	50 37N.	3 27W	
Torbay	Eu.	England	Eng. Chan.	50 34N.	3 38W	5 1
Tornea	Eu.	Sweden	G. Bothnia	65 51N.	23 10 E.	
R. Tortoſa	Eu.	Spain	Medit. Sea	40 47N.	1 03 E.	
I. Tortuga	Am.	Ter. Firm.	Atl. Ocean	11 00N.	64 23W	
I. Tory	Eu.	Ireland	W. Ocean	55 09N.	8 30W	
Toulon	Eu.	France	Medit. Sea	47 07N.	6 02 E.	
C. Trefalgar	Eu.	Spain	Atl. Ocean	36 06N.	5 38W	
I. Tremiti	Eu.	Italy	Medit. Sea	42 09N.	15 40 E.	
C. de Tres forcas	Af.	Barbary	Medit. Sea	35 30N.	2 11W	
I. Trialles	Af.	India	Ind. Ocean	19 30 S.	101 25 E.	
I. Trinity	Am.	Braſil	Atl. Ocean	20 25 S.	23 35W	
I. Trinidada, E. pt.	Am.	Ter. Firm.	Atl. Ocean	10 38N.	60 27W	
Trinity Bay, Ent.	Am.	Newf Ind.	Atl. Ocean	48 55N.	50 20W	
Trieſt	Eu.	Carniola	Adriat. Sea	45 51N.	14 03 E.	
Trinquemali	Af.	I. Ceylon	Indian Oce.	8 50N.	83 24 E.	
Tripoli	Af.	Syria	Levant	34 53N.	36 07 E.	
Tripoly	Af.	Barbary	Medit. Sea	32 54N.	13 10 E	
G. Triſte	Am.	Terra Fir.	Atl. Ocean	10 19N.	67 41W	
I. Triſtian d'A-cunha	Af.	Caffres	S. Atl. Ocean	37 12 S.	13 23W	
Is. Tromſound	Eu.	Lapland	N. Ocean	70 20N.	19 00 E.	
Truxilla	Am.	Peru	South Sea	8 00 S.	78 35W	
Tunder	Eu.	Denmark	W. Ocean	55 00N.	9 35 E.	
Tunis	Af.	Barbary	Medit. Sea	36 47N.	10 16 E.	
Turin	Eu.	Italy	R. Po	44 50N.	7 45 E.	
I. Turks	Am.	Bahama	Atl. Ocean	21 45N.	70 30W	

Vale

ames of Places.	Con.	Country.	Coaſt.	Latitude.	Longitud.	H. Water.
V				° ′	° ′	
alencia	Eu.	Spain	Medit. Sea	39 30N.	0 40W	
. Valery	Eu.	France	Eng. Chan.	50 10N.	0 56E.	10h. 30m.
lona	Eu.	Turkey	Med. Sea	40 55N.	21 15E.	
lparais	Am.	Chili	S. Ocean	33 00 S.	72 14W	
annes	Eu.	France	B. Biſcay	47 39N.	2 41W	0 15
Vela	Am.	Ter.Firm.	Atl. Ocean	12 15N.	71 20W	
nice	Eu.	Italy	Medit. Sea	45 25N.	12 10E.	
ra Cruz	Am.	NewSpain	G. Mexico	19 00N.	97 53W	
Verd	Af.	Negrolnd.	Atl. Ocean	14 43N.	17 05W	
Verkins	Af.	Siam	Ind. Ocean	2 22N.	96 48E.	
ma	Eu.	Sweden	G. Bothnia	63 45N.	21 10E.	
cegapatam	Af.	India	B. Bengal	17 30N.	84 02E.	
Victory	Am.	Patagonia	S. Ocean	52 05 S.	72 50W	
enna	Eu.	Germany	R. Danube	48 13N.	16 28E.	
go	Eu.	Spain	Atl. Ocean	42 00N.	8 35W	
St. Vincent	Am.	Paraguay	Atl. Ocean	23 55 S.	45 11W	
St. Vincent	Eu.	Portugal	Atl. Ocean	36 41N.	8 42W	
St. Vincent	Af.	C. Verd	Atl. Ocean	17 17N.	23 44W	
t. Vincent	Am.	Caribbe	Atl. Ocean	13 05N.	61 05W	
St. Vincent	Af.	Guinea	Eth. Ocean	4 30N.	7 41W	
Virgin Mary	Am.	Patagonia	Atl. Ocean	52 15 S.	64 20W	
Virgins	Am.	Antil. Is.	Atl. Ocean	18 28N.	64 41W	
Volo	Eu.	Turkey	Archipelago	39 07N.	23 23E.	
Voltas	Af.	Guinea	Atl. Ocean	5 52N.	1 10E.	
Voltas	Af.	Caffres	Atl. Oce.	28 04 S.	16 18E.	
ſal	Eu.	Sweden	R. Sala	59 52N.	17 50E.	
aniberg	Eu.	Denmark	Balt. Sea	55 54N.	12 58E.	
Uſhant	Eu.	France	Eng. Chan.	48 30N	4 55W	6 00
Uſtica	Eu.	Italy	Medit. Sea	38 43N.	13 33E.	
ulcano	Eu.	Italy	Medit. Sea	38 29N.	15 33E.	
W						
Wager	Am.	New Wales	Hudſ. Bay	61 05N.	89 37W	
Walſingham	Am.	New Brit.	Hudſ. Str.	62 42N.	78 00W	
rdhus	Eu.	Lapland	N. Ocean	70 35N.	32 45E.	
rſaw	Eu.	Poland	R.Viſtula	52 14N.	21 10E.	
terford	Eu.	Ireland	St. Geo. Ch.	52 07N.	7 52W	4 30
tling Iſle	Am.	Bahama	Atl. Ocean	23 42N.	74 22W	
lls	Eu.	England	Germ. Oce.	53 07N.	1 00E.	6 00
ſtern Iſles	Af.	Diemen'sInd	S. Ocean	42 50 S.	138 40E.	
ſtern ſles S. pt.	Eu.	Scotland	W. Ocean	56 46N.	7 40W	
N. pt.				58 35N.	6 37W	
Weſtmania	Eu.	Iceland	W. Ocean	63 55N.	25 30W	
Veſtrol	Eu.	Lapland	N. Ocean	69 15N.	24 00E.	
xford	Eu.	Ireland	St. Geo. Ch.	52 13N.	7 16W	
ymouth	Eu.	England	Eng. Chan.	50 40N.	2 34W	6 00
ale's Back	Eu.	Iceland	W. Ocean	63 44N.	17 05W	
ale's Head	Eu.	Greenlnd	N. Ocean	77 18N	21 30E	
ale Rock	Eu.	Azores	Atl. Oce.	39 49N	22 35W	
itby	Eu.	England	Germ. Oce.	54 30N	0 50W	3 00

Names of Places.	Con.	Countries.	Coaſt.	Latitude.	Longitud.	H. Wat
				° ′	° ′	
Whitehaven	Eu.	England	Iriſh Sea	54 25N.	3 15W	
Wicklow	Eu.	Ireland	St. Geo. Ch.	52 50N	6 30W	
Windaw	Eu.	Courland	Balt. Sea	57 08N.	22 20 E	
I. Wight N. end	Eu.	England	Engl. Chan.	50 47N.	1 25W	0h. 0
S. end				50 34N.	1 25W	
E. end				50 41N.	1 09W	
W. end				50 41N.	1 46W	
Is. Prince William	Af.	———	S. Sea	16 45 S.	177 55 E.	
Winchelſea	Eu.	England	Engl. Chan	50 58N.	0 50 E.	0 45
Wintertoneſs	Eu.	England	Germ. Oce.	53 02N.	1 22 E.	9 0
Wiſbuy in I. Gotland	Eu.	Sweden	Balt. Sea	57 40N.	19 50 E.	
C. Wrath, or Faro head	Eu.	Scotland	W. Ocean	58 44N.	4 50W	
Wybourg	Eu.	Finland	G. Finland	60 55N	30 20 E.	
Y						
Yamboa	Af.	Arabia	Red Sea	24 25N	38 54 E.	
Yarmouth	Eu.	England	Germ. Oce.	52 55N	1 40 E.	9 45
Yas de Amber	Af.	Zangueb.	Ind. Ocean	0 00N	47 15 E.	
Yellow River	Af.	China	S. Sea	34 06N.	120 10 E.	
Ylo	Am.	Peru	South Sea	17 36 S.	71 08W	
York Fort	Am.	New Wls.	Hudſ. Bay	56 55N.	94 05W	
York new	Am.	New Eng.	Atl. Ocean	41 05N.	74 15W	
Youghall	Eu.	Ireland	St. Geo. Ch.	51 46N.	7 46W	4 30
Z						
Zacatula	Am.	Mexico	South Sea	17 10N	105 00W	
I. Zant	Eu.	Italy	Adriat. Sea	37 50N	21 30 E.	
I. Zanzebar	Af.	Zangueb.	Ind. Ocean	6 55 S	40 10 E.	
Zaro	Eu.	Dalmatia	Mediter. Sea	44 15N	16 55 E.	
New Zeland NW. pt.	Af.	———	S. Ocean	34 20 S.	165 40 E.	
C. Spigie				41 45 S.	162 50 E	
Zenan city	Af.	Arabia	Inland	16 20N.	47 44 E.	
Zerick Sea	Eu.	Dutchlnd.	Germ. Oce.			3 0

Beſide the times of high water in the preceding Table, the followi ones ſerve for coaſts of conſiderable extent, and will nearly ſerve for places on thoſe coaſts.

Finmark, or NNW. coaſt of Lapland, 1 h. 30 m. Jutland Iſles 0 h. 0
Frieſland coaſt 7 h. 30 m. Zeland coaſt 1 h. 30 m.
Flanders coaſt 0 h. 00 m. Picardy and Normandy coaſts 10 h. 30
Biſcay, Gallician and Portugal coaſts 3 h. 00 m.
Iriſh W. coaſt 3 h. 00 m. Iriſh S. coaſt 5 h. 15 m.

THE ELEMENTS OF NAVIGATION.

BOOK VI.
OF PLANE SAILING.

SECTION I.
Definitions and Principles.

6. NAVIGATION is the art of conducting a ſhip from one port to another.

This art may be divided into two parts; namely, Mechanical and Teoretical.

MECHANICAL, or WORKING NAVIGATION, comprehends the art of working a ſhip; that is, of cauſing it to obſerve ſuch motions and di ctions as are aſſigned by the Navigator.

his art muſt be learned on ſhipboard, and in the practice of ſailing.

HEORETICAL NAVIGATION, or the art of Piloting, concerns th e methods whereby the Navigator, or Pilot, diſcovers in what tract th ſhip muſt ſteer, ſo as to arrive ſafely at the intended port.

The art of Piloting is either common or proper.

OMMON PILOTING is that knowledge which teaches how to coaſt al g ſhore, or to ſail within ſight of land.

ROPER PILOTING is the art of ſailing to diſtant places through the O an, and out of ſight of land.

he art of proper piloting (which partly includes that of common pilot g) chiefly depends on a right application of the principles contained in e preceding books.

661. The navigating or conducting a ſhip thro' the Ocean to diſt t countries, depends on the Navigator's being beforehand furniſhed w h the following elements.

1ſt. A Table of the latitudes and longitudes of the moſt remarka e parts of the Sea coaſts, Iſlands, Rocks, Shoals, &c. in the frequen d parts of the world.

2d. Maps or Charts of the Seas and Lands; together with the dep s of water, and the times and ſetting of the tides upon the coaſts he n y have occaſion to approach near.

3d. The uſe and application of ſeveral Inſtruments neceſſary to p t out the way the ſhip is to ſteer, to meaſure the rate ſhe runs at, d to find the place ſhe is in at any time.

4th. A ſufficient ſtock of Mathematical learning to enable him rig y to uſe the obſervations that may be deduced from the preceding e ments.

The latitudes and longitudes of places cannot be otherwiſe obtain , than from proper obſervations made by perſons who have been in the places: conſequently, the collecting a ſufficient number of theſe muſt e the work of many ages. And hence ariſes the great uncertainty of e poſitions of many places, and even of the little knowledge we have f many parts on the ſurface of the Terraqueous globe. See Table, t art. 659.

662. The Maps of Countries, and the Charts of the Ocean and th r boundaries, are made chiefly from the catalogue of the latitudes and l gitudes of places: But where theſe are partly wanting, and a good c lection of the poſitions and diſtances of places can be obtained, the places may be inſerted in the map as truly as the others whoſe latitu s and longitudes are known.

The moſt natural way of delineating the ſurface of the earth, is o do it on a ſphere; for then every place on the Globe, laid down by s latitude and longitude, will have the ſame poſition with reſpect to ot r places, as they really have on the ſurface of the earth. But as a Gl e is a bulky thing, and not ſo eaſily managed or worked on as a plane ; therefore has the repreſentation of the ſurface of the earth been m e on planes, and theſe are called *Maps* or *Charts*.

In the conſtructing of Maps and Charts, great care ſhould be tak , that the ſeveral parts in them preſerve their poſition one to the other n the ſame order as they do on the Earth; and 'tis likely, that the find g out of proper methods to do this, gave riſe to the ſeveral methods f projection.

663. There are many ways of conſtructing Maps and Charts; t they chiefly depend on two principles.

Fi,

Firſt, From conſidering the earth as a large extended flat ſurface: The Charts made on this ſuppoſition, are uſually called PLANE CHARTS.

Secondly, From conſidering the earth as a ſphere: The Charts made on his principle are ſometimes called GLOBULAR CHARTS, or MERCATORS CHARTS, or REDUCED CHARTS, or PROJECTED CHARTS.

Plane Charts, when made for any large extent of ſeveral degrees in igh latitudes, are very erroneous; for in them the difference of longi-ude between any two Meridians, taken at the Equator, is uſed as the ſtance of thoſe meridians in all latitudes; and conſequently the diſ-nces of places in high latitudes will be too great, and thereby their ue poſitions will not be preſerved: But Charts made for a ſmall part, as degree or two in length and breadth, may be reckoned as tollerably xact, eſpecially if thoſe places be within the *Torrid Zone*; nay, a Plane hart made for all this Zone will differ but little from the truth.

SECTION II.

54. *The conſtruction and uſe of the Plane Chart.*

CONSTRUCTION.

1ſt. Having determined the limits of the Chart, that is, how many grees of latitude and longitude, or meridional diſtance, (they being in s Chart the ſame) it is to contain: Suppoſe from the lat. of 20° N. the lat. of 71° N; and from the longitude of London in 0 deg. to lon. of 50° W.; then fix on ſome ſcale of equal parts, ſuch where- l the chart may be contained within the ſize of the ſheet it is intended be drawn on. In the chart annexed, ſee Plate II. the ſcale is ſuch, t each degree of latitude and longitude is $\frac{1}{8}$th part of an inch.

2d. Make a parallelogram (160) ABCD, whoſe length AB from north t ſouth ſhall contain 51 degrees, the difference of latitude between the lits of 20° and 71°; and the breadth AD from eaſt to weſt ſhall con- tn the propoſed 50 degrees of longitude, the degrees being taken from tl ſaid ſcale of 8 degrees to an inch; and this parallelogram will be the undaries of the chart.

3d. About the boundaries of the chart, make (172) ſcales containing tl degrees, halves and quarters of degrees (if the ſcale is large enough); dwing lines acroſs the chart thro' every 5 or 10 degrees; and the ſhet is then fitted to receive the places intended to be delineated threon.

th. On a ſtrait ſlip of paſtboard, or ſtiff paper, let the ſcale of the drees and parts of degrees of longitude in the line AD, be laid cloſe tothe edge; and the diviſions numbered from the right hand towards th left, being all weſt longitude.

5th. Seek in the table (art. 659) for the latitudes and longitudes f the places contained within the propoſed limits; and let them be wr out in the order in which they increaſe in latitude.

6th. Then to lay down any place, lay the edge of the paſtboard ſc to the diviſions on each ſide the chart, ſhewing the latitude of the plac; ſo that the beginning of its diviſions fall on the right hand border A; and againſt the diviſion ſhewing the longitude of the given place ma a point, and this gives the poſition of the place propoſed; and in li manner are all the other places to be laid down.

7th. Draw waving lines from one point to the other, where the co is contiguous, and thus the repreſentation of the lands within the pr poſed limits will be delineated.

8th. Write the names to the reſpective parts, and in ſome conveni place inſert a compaſs, and the chart will be compleated.

The uſe of the Plane Chart.

665. *To find the lat. and lon. of any propoſed place in the Chart.*

Take with a pair of compaſſes the leaſt diſtance between the giv place and ſome parallel of latitude; this diſtance applied (the ſame wa to the graduated meridian on the border of the chart, keeping one po on the ſame parallel of latitude, the other point will ſhew the degrees f latitude the propoſed place is in.

And in like manner, the diſtance between the given place and ſo meridian, applied (the ſame way) to the graduated parallel on the t or bottom of the chart, will ſhew its degrees of longitude.

Thus the diſtance between Cape Fineſterre and the parallel of latitu of 40°, laid on the border from 40° upwards, gives 43° 15′ N. for Ca Fineſterre's latitude: And the diſtance of the Cape from the Meridi paſſing thro' 10° of longitude, being laid on the bottom border from 1 towards the right, gives 9° 20′ W. for the longitude.

666. *Two places being given, ſuppoſe Cape Clear and the Iſland of Michael's, to find the bearing and diſtance between them.*

Lay a ruler by the two places, C. Clear and St. Michael's, take t neareſt diſtance between the centre of the compaſs and the edge of t ruler; in this poſition ſlide one point along the ruler, and the other po will run along that point of the compaſs ſhewing the bearing, which this caſe is S. W.; that is, St. Michael's lies to the S. W. of C. Cle or C. Clear to the N. E. of St. Michael's.

The diſtance between the two places applied to the graduated parall from 0 degrees, will give the number of degrees, which converted in miles ſhews their diſtance.

Thus the diſtance from Cape Clear to St. Michael's will be found be about 15° 25′, which multiplied by 60 gives 925 miles.

667. *The diſtance ſailed on a given courſe, and from a given place, being known, to find the place the ſhip is in. Thus ſuppoſe a ſhip ſails from ape Clear S.W. for* 925 *miles: Required her preſent place?*

Reduce the given miles (925) into degrees and minutes, and take hem (15° 25′) with one pair of compaſſes from the graduated ſcales.

Lay a ruler by the centre and the given point of the compaſs (S.W.); ke the neareſt diſtance between (Cape Clear) the place ſailed from and e edge of the ruler with another pair of compaſſes; in this poſition, de one point along the ruler until the other point is got as far diſtant om the given place as is the given diſtance, which is found by apply-g the opening of the other pair of compaſſes from (Cape Clear) the ven place, till the points of both pair of compaſſes meet; and that ill give the preſent place of the ſhip, which will be found in the lati-de and longitude of St. Michael's; and theſe are known by art. 665.

The Mariner working by the preceding precepts will preſerve his art free from a multitude of lines: But when this is not regarded (as deed it is ſcarely worth while), the operations will become ſomewhat orter.

668. *The latitude of a place* (A), *and its bearing from a given place* (B) *ng known; to find that place* (A) *on the chart, and its diſtance from* B.

Thro' the given place B draw a line parallel to the given point of compaſs, or bearing; then an eaſt and weſt line drawn thro' the itude of A, its interſection with the former line will give the place ight. The diſtance may be meaſured as in art. 666.

669. *The latitude of a place* (A), *and its diſtance from a given place* (B) *ng known; to find the place of* A *on the chart.*

Draw an eaſt and weſt line thro' the latitude of A; take the given tance in degrees from the graduated ſcale; then this diſtance being ap-ed from the given place B will cut the ſaid eaſt and weſt line in the uired place of A.

670. *The longitude of a place* A, *and its bearing from a given place* B *ng known; to find the place of* A *on the chart.*

Draw a meridian thro' the longitude of A; then the given diſtance en as before and applied from B, will cut the ſaid meridian in the re-red place of A.

671. *The longitude of a place* A, *and its bearing from a given place* B *g known; to find the place of* A *on the chart.*

Thro' the given place B draw the given bearing. (666)

Draw a meridian thro' the longitude of A, and its interſection with ſaid bearing will be the place of A.

nd in this manner may every poſſible caſe of ſailing by the plane t be readily ſolved: But as the accuracy of theſe ſolutions cannot be ended upon nearer than 5 or 6 minutes more or leſs than the truth; efore the more careful Navigators depend on computation, as will be wn in the following ſections.

SECTION III.

Of Plane Sailing.

672. PLANE SAILING is the art of navigating a ſhip upon princi deduced from the notion of the earth's being an extended plane.

On this ſuppoſition, the meridians are eſteemed as parallel right lin the parallels of latitude are at right angles to the meridians, the leng of the degrees on the meridians, equator and parallels of latitude, every where equal; and the degrees of longitude are reckoned on the rallels of latitude as well as on the equator.

673. The PLANE CHART is a map or repreſentation of the ſeve parts of the earth, laid down from theſe principles, according to th latitudes and longitudes, on a ſheet of paper, or other flat ſurface. (6

When the parts of the earth are thus delineated on a plane, it eaſy to ſee the tracks by which a ſhip may go from one place to other; and alſo what angle this track makes with the meridian: A ſhips at ſea are kept in this track or path by the help of an inſtrum called the Mariner's Compaſs.

674. The MARINER'S COMPASS is an artificial repreſentation of horizon of every place, by the means of a circular piece of paper cal a Card, divided like the horizon into degrees and points, which are cal Rhumbs: Now the card being properly fixed to a piece of ſteel cal a Needle, that has been touched with a loadſtone (whoſe property ſuch as to cauſe one end of the needle, ſo touched, to point towards north, when turning freely on ſomething ſupporting it), all the poi of the card will be directed towards their correſponding points of horizon.

From this conſtruction of the Mariner's compaſs it follows, that every place the north point of the card ſhews the poſition of the ridian in that place; and ſome one rhumb or point of the card will incide with, or be directed along, the track that makes any giv angle with the meridian: Conſequently by the help of the card compaſs a ſhip may be kept on any propoſed track or courſe.

675. A RHUMB LINE is a right line drawn from the centre of compaſs to the horizon; and is named from that point of the horizon falls in with.

676. The COURSE is an angle which any Rhumb line makes with meridian, and is ſometimes reckoned in degrees, and ſometimes points of the compaſs.

677. DISTANCE is the number of leagues, miles, &c. intercep between two places reckoned on a Rhumb; or it is the way or leng a ſhip has gone on a direct courſe in a given time.

678. DEPARTURE is the eaſt or weſt diſtance of a ſhip from meridian of ſome noted place, reckoned on its parallel of latitude the Plane Chart; and therein it is the ſame as the difference of lon tude.

67

679. If a ſhip ſails either due north or ſouth, ſhe ſails on a meridi- n, makes no departure, and her diſtance and difference of latitude are e ſame.

If a ſhip ſails either due eaſt or weſt, ſhe runs on a parallel of lati- de, makes no difference of latitude, and her departure and diſtance are e ſame.

680. The difference of latitude and departure always make the legs of right angled triangle, whoſe hypothenuſe is the diſtance the ſhip has led.

When the courſe is 45 degrees, or 4 points, the difference of latitude d departure are equal.

When the courſe is leſs than 45 degrees, or 4 points, the difference latitude is greater than the departure.

But when the courſe is greater than 4 points, or 45 degrees, the de- ture is greater than the difference of latitude.

681. When a figure relating to a ſhip's courſe is to be conſtructed, muſt firſt be conſidered whether the ſhip is ſailing northward or ſouth- rd; and whether ſhe goes to the eaſtward or weſtward of the place departed from; for the lines in the figure muſt be drawn accord- ly.

Thus. Let the upper part of the paper, or what the figure is drawn always repreſent the north, then the lower part will be ſouth, the r t hand ſide eaſt, and the left hand ſide the weſt.

Draw a north and ſouth line to expreſs the meridian of the place the ſh ſails from; then if the courſe is to the ſouthward, mark the upper e of the line for the place ſailed from: But if the courſe is north- w d, mark the lower end for that place.

Thro' the point ſailed from, draw a line perpendicular to the meridi- a to repreſent the parallel of latitude of that place; and from the ſame p nt, with the chord of 60 degrees, deſcribe a quadrantal arc on the ea ſide of the meridian, if the courſe is eaſtward, or on the weſt ſide, if he courſe is to the weſtward.

When the courſe is given, the chord of the degrees, or points ex- pr ſing it, is to be taken with a pair of compaſſes either from the ſcale of hords or of rhumbs *; and is always to be laid off on the qua- dr ntal arc, beginning at the meridian.

The line expreſſing the diſtance the ſhip has run, is always to be dr vn from the centre of the quadrant or point ſailed from, thro' that po it of its arc which limits the courſe.

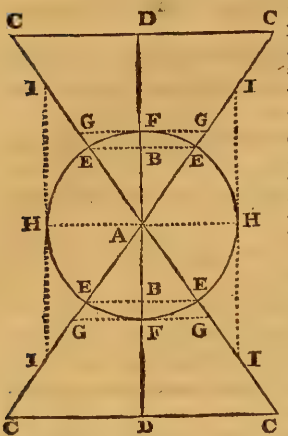
The difference of latitude, in leagues or miles, taken with the com- pa s from a ſcale of equal parts, is ever to be laid on the meridian, re oning from the centre of the quadrant.

---

* A quadrant, or arc of 90°, being divided into 8 equal parts, and each of heſe into quarters; then if from one end of the arc the ſeveral diviſions be anſferred to the chord of 90°, as in art. 213, a line of rhumbs is thereby co ructed; whoſe uſe is the ſame as the chords, namely, to make an angle wh e meaſure is given in points inſtead of degrees.

The departure is to be a right line parallel to the eaſt and weſt l before drawn, and joins the ends of the lines expreſſing the diſta and difference of latitude.

682. In the annexed figure, ſuppoſe the circle FHFH to repreſent horizon of the place A, from whence the ſ ſails; AC the rhumb ſhe ſails on, and C place come to; then HH repreſents the par lel of latitude ſhe ſailed from, CC the para of the latitude arrived in: So that AD comes the difference of latitude, DC the parture, AC the diſtance ſailed, the angle D is the courſe, and the angle DCA is the co plement of the courſe.



Theſe particulars will be alike repreſent whether the ſhip ſails in the N. E. or N. V S. E. or S. W. quarters of the horizon.

Hence it is evident, that the difference latitude, departure and diſtance, form the ſi of a right angled triangle, whoſe angles the courſe, its complement and the right gle, whoſe ſine is radius; therefore amo theſe four things, *courſe*, *diſtance*, *diff. lat.* and *departure*, any two them being given, the reſt are to be found by plane trigonometry.

683. But for the ready working of any ſingle courſe, there is a ble, called a *Traverſe-Table*, uſually annexed to Treatiſes of this kin which is ſo contrived, that by finding therein the given courſe and diſtance not exceeding 100 miles, the diff. lat. and departure is had inſpection: The courſe is to be found at the top of the table, wh under 4 points, or 45 deg.; but at the bottom of the table when it e ceeds 45 deg. Each column ſigned with a courſe conſiſts of two par one for the diff. lat., marked *Lat.*; the other for the departure, mark *Dep.*; which names are both at the top and bottom of theſe colum The diſtance is to be found in the column marked *Diſt.* next the marg of the page.

This table will ſerve for greater diſtances, by taking their halv thirds, fourths, &c. and doubling, tripling, quadrupling, &c. the di lat. and departure found to thoſe parts of the diſtance.

But the traverſe table contained in this book, has the diſtances continu to 120, which is a number more capable of ſubdiviſions than 100: E ſides, the table is divided into two parts; the firſt contains the wh points and quarter points in a quadrant; and the ſecond part is fitted every degree and quarter of a degree in the quadrant; whereby t courſe and diſtance, reſulting from a day's work, is more accurately o tained than by the common traverſe tables.

684. All the proportions that can ariſe in Plane ſailing are exhibit in the following table; they refer to the preceding figure, where A AF, or AH repreſent the radius of the tables, EB the ſine of the cour GF its tangent, and AG its ſecant; AB ſtands for the ſine of the co plement of the courſe, HI its tangent, and AI its ſecant.

Th

Theſe proportions are here inſerted to exerciſe the learner in reaſon-g on the relations ſubſiſting between theſe lines and thoſe repreſenting diſtance, departure and difference of latitude: But in what follows, ly the analogies in the firſt column, and one againſt the laſt caſe in ſecond column, will be uſed; the others being rather matters of rioſity than uſe.

ſe	Given	Req.	Solution by ſines	Solution by tangents and ſecants	
	——	—	by ſim. △ ADC, ABE	by ſim. △ ADC, AFG	by ſim. △ ADC, AHI.
	∠A, AC	AD DC	AE : AB :: AC : AD AE : EB :: AC : DC	AG : AF :: AC : AD AG : FG :: AC : DC	AI : IH :: AC : AD AI : AH :: AC : DC
	∠A, AD	AC DC	AB : AE :: AD : AC AB : BE :: AD : DC	AF : AG :: AD : AC AF : FG :: AD : DC	IH : AI :: AD : AC IH : AH :: AD : DC
	∠A, DC	AC AD	BE : AE :: DC : AC BE : AB :: DC : AD	FG : AG :: DC : AC FG : AF :: DC : AD	AH : AI :: DC : AC AH : HI :: DC : AD
	AD, AC	∠A DC	AC : AD :: AE : AB AE : EB :: AC : DC	AD : AC :: AF : AG AF : FG :: AD : DC	
	AC, DC	∠A AD	AC : DC :: AE : EB AE : AB :: AC : AD		DC : AC :: AH : AI AH : HI :: DC : AD
	AD, DC	∠A AC		AD : DC :: AF : FG AF : AG :: AD : AC	DC : AD :: AH : HI AH : AI :: DC : AC

85. To aſſiſt the learner, the proportions hereafter uſed are given their nautical terms.

e	Given	Required	SOLUTIONS.
	Courſe & Diſtance	Diff. lat. Depart.	Rad : Diſt :: Coſ. Cou : Diff. lat. N° I. Rad : Diſt :: ſin. Cou : Depart. N° II.
	Courſe Diff. lat.	Diſtance Depart.	Coſ. Cou : Diff. lat :: Rad : Diſtance. N° III. Coſ. Cou : Diff. lat :: ſin. Cou : Depart. or by N° II.
	Courſe Depart.	Diſtance Diff. lat.	Sin. Cou : Depart :: Rad : Diſt. N° IV. Sin. Cou : Depart :: Coſ. Cou : Diff. lat. or by N° I.
	Diſtance Diff. lat.	Courſe Depart.	Diſt : Rad :: Diff. lat : Coſ. Cou. N° V. Rad : Diſt :: ſin. Cou : Depart. by N° II.
	Diſtance Depart.	Courſe Diff. lat.	Diſt : Rad :: Depart : ſin. Cou. N° VI. Rad : Diſt :: Coſ. Cou : Diff. lat. by N° I.
	Diff. lat. Depart.	Courſe Diſtance	Diff. lat : Depart :: Rad : tan. Cou. N° VII. Sin. Cou : Depart :: Rad : Diſt. by N° IV.

heſe proportions (or Canons as they are uſually called by Mariners), ar applied to the numeral ſolutions of all the varieties of ſingle courſes in he following ſection.

686. A TABLE of the angles which every Rhumb, or point of compaſs, makes with the meridian.

NORTH.	SOUTH.	Points.		D.	M.	NORTH.	SOUT
		0	¼	2	49		
		0	½	5	37½		
		0	¾	8	26		
N. b. E.	S. b. E.	1	0	11	15	N. b. W.	S. by W
		1	¼	14	04		
		1	½	16	52½		
		1	¾	19	41		
N. N. E.	S. S. E.	2	0	22	30	N. N. W.	S. S. W.
		2	¼	25	19		
		2	½	28	07½		
		2	¾	30	56		
N. E. by N.	S. E. b. S.	3	0	33	45	N.W. b. N.	S.W. b.
		3	¼	36	34		
		3	½	39	22½		
		3	¾	42	11		
N. E.	S. E.	4	0	45	00	N. W.	S. W.
		4	¼	47	49		
		4	½	50	37½		
		4	¾	53	26		
N. E. b. E.	S. E. b. E.	5	0	56	15	N.W. b.W.	S.W. b.
		5	¼	59	04		
		5	½	61	52½		
		5	¾	64	41		
E. N. E.	E. S. E.	6	0	67	30	W. N. W.	W. S. W
		6	¼	70	19		
		6	½	73	07½		
		6	¾	75	56		
E. b. N.	E. b. S.	7	0	78	45	W. b. N.	W. b. S
		7	¼	81	34		
		7	½	84	22½		
		7	¾	87	11		
EAST.	EAST.	8	0	90	00	WEST.	WES

Before the learner begins his caſes of Plane ſailing, he ſhould ſo well acquainted with his Compaſs, or this table, as to be readily a to tell how many points any of theſe courſes or Rhumbs are diſt from the meridian, or from the parallel.

SECTION IV.

Of ſingle courſes.

687. Case I. Given the courſe ſteered, and the diſtance run: Required the difference of latitude and departure.

Exam. *A ſhip from the latitude* 47° 30′ *N. has ſailed S. W. b. S.* 98 *les: What Lat. is ſhe in, and what Dep. has ſhe made?*

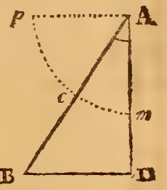
By the Traverse Table. (711)

Find the given courſe at the top or bottom of the table among the ints or degrees; and in that column, right againſt the diſtance taken its column, ſtand the diff. lat. and departure in their columns.

Thus the courſe is S. W. b. S. or 3 points, in which column, and inſt the diſtance 98 in the column of diſtances, ſtand 81,5 miles for diff. lat.; and 54,45 miles for the departure.

By Construction. (681)

1 Draw the meridian AD, and make the quadrant *n c p.*
2 Make *m c* = rhumb of 3 points, and thro' *c* draw equal to 98 miles.
3 Draw BD parallel to *p* A, meeting AD in D.
en AD the diff. lat. meaſures about 81½ miles.
d DB the departure meaſures about 54,4 miles.



By Computation.

e courſe being 3 points = 33° 45′. The comp. courſe is 5 pts. = 56° 15′.
find the diff. latitude. To find the departure.

Rad	= 90° 00′	10,00000	As Rad	= 90° 00′	10,00000
Diſt.	= 98 m.	1,99123	To Diſt.	= 98 m.	1,99123
coſ. Co.	= 33° 45′	9,91985	So ſin. Cou.	= 33° 45′	9,74474
diff. lat.	= 81,48	1,91108	To Dep.	= 54,45	1,73597

By Gunter's scale.

n the line of ſine Rhumbs, the extent from Rad. or 8 points to oints, applied to the line of numbers will reach from 98 in either e to 54,4.

nd the extent from 8 points to 5 points among the Rhumbs, reaches n 98 to 81,5 on the line of numbers.

r thus. The extent from Radius or 8 points in the S. R. to 98 in Nos. will reach from 3 points in the Rhumbs to 54,4 in the Nos. and ſame extent will reach from 5 points in the Rh. to 81,5 in the Nos.

60)81(The Lat. from 47° 30 N.
diff. Lat. 1 21 S.
1° 21′
Lat. in 46 09 N. Dep. 54,4 miles Weſt.

he lines on the Gunter's ſcale marked S. R. and T. R. ſignifying *Sine Rumbs* and *Tangent Rhumbs*, are the logarithmic ſines and tangents anſwering to e degrees and minutes in each point and quarter point of the Compaſs, ſferred from the ſcales of Log. ſines and Log. tangents.

688. Case II. Given the courſe ſteered, and difference of latitud
Required the diſtance run, and the departure.

Exam. *A ſhip has ſailed S. E. b. S. from the Lat. 47° 30′ N. to Lat. 46° 08′ N. What diſtance has ſhe run, and what departure has made?*

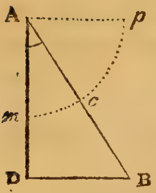
By the Traverse Table. (711)

Find the courſe among the degrees, and the diff. lat. in its colum right againſt which ſtand the departure and diſtance in their columns.

Now taking 46° 08′ from 47° 30′, Remains 1° 22′ = 82 m. the di lat.

Then the courſe S. E. b. S. is 3 points, under which in the colu of Lat. the neareſt number to 82 is 82,3, the correſponding departu is 55, and the diſtance is 99 miles.

By Construction.



1ſt. Deſcribe the quadrant A *m c p*.
2d. Make *m c* = rhumb of 3 points, and conti A *m* till AD = 82 miles.
3d. Thro' D draw DB parallel to A *p*, meeting line AB drawn thro' *c*, in the point B.
Then the diſtance AB meaſures about 99 miles.
And the departure DB meaſures about 55 miles.

By Computation.

The courſe 3 points = 33° 45′.
To find the diſtance.

As coſ. Co.	=	33° 45′	0,08015
To diff. lat.	=	82 m.	1,91381
So Rad	=	90° 00′	10,00000
To Diſt.	=	98,62	1,99396

The comp. courſe is 5 pts. = 56° 1
To find the departure.

As coſ. Co.	=	33° 45′	0,08
To diff. lat.	=	82 m.	1,91
So ſin. Cou.	=	33° 45′	9,744
To Dep.	=	54,79	1,73

By Gunter's scale.

On the line of ſine Rhumbs, the extent from 5 points to 8 points radius, will on the line of numbers reach from 82 to 99.

And the extent from 5 points to 3 points on the S. R. will reach fr 82 to 55 on the line of numbers.

Or thus. The extent from 5 points in the ſine rhumbs, to 82 mi in the line of numbers, will reach from 8 points in thoſe rhumbs 99 in the numbers; and the ſame extent will reach from 3 points the rhumbs to 55 in the numbers.

Note. In all theſe caſes, wherever the coſ. Cou. is uſed, the deg. put do is the courſe itſelf, yet the log. belongs to the comp. of that courſe.

68

689. Case III. Given the courſe ſteered and the departure: Required the diſt. run, and diff. latitude.

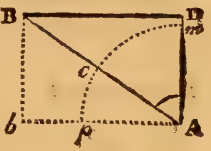
Exam. *A ſhip from Lat.* 47° 30′ *N. ſailing N. W. b. W. finds ſhe has ade* 82 *miles of departure: What is her diſtance run, and what Lat. is ſhe nw in?*

By the Traverse Table. (711)

Find the courſe among the degrees, and the departure in its column; ght againſt which ſtand the difference of latitude and the diſtance in eir reſpective columns.

Now the courſe N. W. b. W. is 5 points, over which in the column departure, the neareſt number to 82, is 82,3; and the correſponding ff. latitude is 55 miles, and the diſtance is 99 miles.

By Construction.



1. Deſcribe the quadrantal arc A *mcp*.
: Make *mc* = rhumb of 5 points, and continue *p* till A *b* = 82 miles.
. Thro' *b* draw *b* B parallel to A *m*, meeting the e AB, drawn thro' *c*, in B.
1. Thro' B draw BD parallel to *b* A, meeting A *m* ntinued, in D.

nen the diſtance AB meaſures about 99 miles.
nd the diff. lat. AD meaſures about 55 miles.

By Computation.

The courſe 5 points is 56° 15′.
To find the diſtance.

ſin. Co.	=	56° 15′	0,08015
dep.	=	82 m.	1,91381
Rad	=	90° 00′	10,00000
diſt.	=	98,62	1,99396

The comp. courſe is 3 pts. = 33° 45′.
To find the diff. latitude.

As ſin. Co.	=	56° 15′	0,08015
To dep.	=	82 m.	1,91381
So coſ. Co.	=	56° 15′	9,74474
To diff. lat.	=	54 79	1,73870

By Gunter's scale.

On the line of ſine rhumbs, the extent from 5 points to 8 points or r ius, will on the line of numbers reach from 82 to 99.

And the extent from 5 points to 3 points on the line of S. R. will rch from 82 to 55 on the line of numbers.

Or thus. The extent from 5 points in the ſine rhumbs to 82 miles i the line of numbers, will reach from 8 points in the rhumbs to 99 i the numbers: And the ſame extent will reach from 3 points in the r umbs to 55 in the numbers.

Lat. from	47°	30′	N.
Diff. lat.	0	55	N.
Lat. in	48	25	N.

690.

690. Case IV. Given the diſtance and difference of latitude: Required the courſe and departure.

Exam. *A ſhip from Lat. 47° 20′ N. ſails between the north and e 98 miles, and is arrived in Lat. 48° 42′ N. What courſe did ſhe ſtee and what Dep. has ſhe made?*

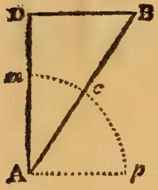
By the Traverse Table. (712)

Seek in the table, till againſt the diſtance taken in its column, found the given diff. lat. in one of the following columns; and adjoini to it ſtands the departure, which if leſs than the diff. lat. the courſe found at the top of the column; but if greater, the courſe is found bottom.

Now taking 47° 20′ from 48° 42′ leaves 1° 22′ = 82 m. t diff. lat.

Then ſeeking till againſt diſt. 98, ſtands lat. 82, the neareſt will lat. 81,95, and here the departure is 53,73 m. and the courſe is 33° 1

By Construction.



1ſt. Deſcribe the quadrant A *m c p*.
2d. Continue A *m*, till AD = 82 m.
3d. Thro' D draw DB parallel to A *p*.
4th. On A with the diſtance 98 cut DB in B.
Then the departure DB meaſures about 53 m.
And the courſe DAB is meaſured by the arc *mc* about 33°.

By Computation.

To find the courſe.			To find the departure.		
As diſt.	= 98 m.	8,00877	As Rad	= 90° 00′	10,000
To Rad	= 90° 00′	10,00000	To diſt.	= 98 m.	1,991
So diff. lat.	= 82 m.	1,91381	So ſin. Co.	= 33° 13′	9,738
To coſ. Co.	= 33° 47′	9,92258	To dep.	= 53,69	1,729

By Gunter's scale.

On the line of numbers, the extent from 98 m. to 82 m. will on t line of ſines reach from 90, or radius, to about 57 deg.

And the extent on the line of ſines, from 90° to 33°, will reach the line of numbers from 98 m. to about 53 miles.

Or thus. The extent from 98 m. in the line of numbers, to 90° the line of ſines, will reach from 82 m. in the numbers to about 57° the ſines: And the ſame extent will reach from about 33° in the ſin to about 53 in the numbers.

So that the courſe is N. 33° 15′ E. or N. E. b. N. nearly. And the departure is 53,69 miles to the Eaſtward.

691. Case V. Given the diſtance and departure:
Required the courſe and difference of latitude.

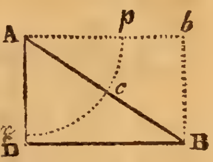
Exam. *From the Lat.* 50° 13′ *N. a ſhip in ſailing between the South ind Eaſt* 98 *miles, makes her departure* 82 *miles: What courſe did ſhe eep, and what Lat. is ſhe arrived at?*

By the Traverse Table. (712)

Seek in the table, till againſt the diſtance taken in its column, be ound the given departure in one of the following columns; and adoining to it ſtands the diff. lat. which if greater than the departure, the ourſe is found at the top of the column; but if leſs, the courſe is found t the bottom.

Now ſeeking till againſt the diſt. 98 ſtands 82, the neareſt will be 1,95, ſigned Dep. at bottom; and here the diff. lat. is 53,73 min. and e courſe is 56° 45′.

By Construction.



t. Deſcribe the quadrant A *n c p*.
l. Continue A *p*, till A *b* = 82 m.; and thro' *b* aw *b* B parallel to A *n*.
l. From A with the diſt. 98 m. cut *b* B in B.
h. Thro' B draw BD parallel to A *b*, meeting A *n* ntinued, in D.
hen the diff. lat. AD meaſures about 53 miles.
nd the courſe DAB is meaſured by the arc *n c* of about 57°.

By Computation.

To find the Courſe.			To find the diff. lat.		
diſt.	= 98 m.	8,00877	As Rad	= 90° 00′	10,00000
Rad	= 90° 00′	10,00000	To diſt.	= 98 m.	1,99123
dep.	= 82 m.	1,91381	So coſ. Cou.	= 56° 47′	9,73863
ſin. Cou.	= 56° 47′	9,92258	To diff. lat.	= 53,69	1,72986

en 50° 13′ N. — 0° 54′ N. = 49° 19′ N. For 53,69 m. is neareſt 54.

By Gunter's scale.

On the line of numbers, the extent from 98 m. to 82 m. will on the li of ſines reach from 90°, or radius, to about 57 deg.

And the extent on the line of ſines, from 90° to 33°, will reach from 9 m. to about 53 m. on the line of numbers.

Or thus. The extent from 98 m. in the line of numbers to 90° in t line of ſines, will reach from 82 m. in the numbers to about 57° in t ſines: And the ſame extent will reach from about 33° in the ſines, t about 53 m. in the numbers.

o that the Courſe is S. 56° 47′ E. or S. E. b. E. nearly.
And the latitude arrived in is 49° 19′ N.

692. Case VI. Given the difference of latitude and departure: Required the courſe and diſtance.

Exam. *A ſhip from Lat.* 48° 32′ *N. is arrived in Lat.* 49° 54′ *and is got* 54 *miles to the weſtward of her departed meridian: What cou did ſhe ſteer, and what is the direct diſtance ſhe has run?*

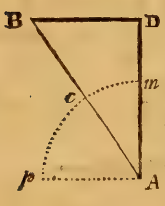
By the Traverse Table. (712)

Seek in the table till the given diff. lat. and departure are found t gether in their reſpective columns; then right againſt them will be fou the diſtance in its column, and the courſe ſtands among the degrees the top or bottom of the column, where the diff. lat. and depart. we found.

Now taking 48° 32′ from 49° 54′, leaves 1° 22′ = 82 m. t diff. lat.

Then in the table it will be found, that the numbers ſtanding tog ther, the neareſt to 82 and 54, are 81,95 and 53,73; the diſtance a ſwering to theſe is 98 m. and the courſe is 33° 15′.

By Construction.



1ſt. Deſcribe the quadrant A *m c p*, and contin A *m* till AD = 82 m.

2d. Thro' D draw DB parallel to A *p*, and equal 54 miles, and draw AB.

Then the diſtance AB meaſures about 98 miles.

And the courſe DAB is meaſured by the arc *mc* of abo 33°.

By Computation.

To find the Courſe.			
As diff. lat.	=	82 m.	8,08619
To depart.	=	54 m.	1,73239
So Rad	=	45° 00′	10,00000
To tan. Cou.	=	33 22	9,81858

To find the diſtance.			
As ſin. Cou.	=	33° 22′	0,259
To dep.	=	54 m.	1,732
So Rad	=	90° 00′	10,000
To diſt.	=	98,18	1,992

By Gunter's scale.

On the line of numbers, the extent from 82 m. to 54 m. will rea on the line of tangents from 45° to about 33°.

And the extent on the line of ſines, from about 33° to 90°, will rea on the line of numbers from 54 m. to about 98 m.

Or thus. The extent from 82 in the line of numbers to 45° in t line of tangents, will reach from 54 in the line of numbers, to abo 33° in the line of tangents.

Alſo, the extent from about 33° in the ſines to 54 in the numbe will reach from 90° in the ſines to about 98 m. in the numbers.

So the Courſe is N. 33° 22′ W. or N. W. b. N. nearly.

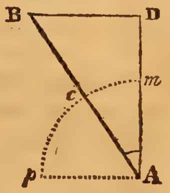
And the diſtance is 98,18 miles.

69

93. *Queſtions to exerciſe the foregoing caſes.*

QUEST. I. *Four days ago we were in Lat. 3° 25′ S.; and have ſince at time run on a direct courſe NW. by N. at the rate of 8 miles an ur: Required our preſent latitude and departure?*

One day = 24 hours: Then 24 × 4 = 96 hours.
And 96 × 8 = 768 miles, the whole diſtance.



CONSTRUCTION.

1. Draw the meridian AD, and deſcribe the qua- ant A m p.

Lay off the courſe 3 points from m to c, and aw the rhumb line AB.

On the rhumb line lay the diſtance from A to and draw BD parallel to p A.

COMPUTATION.

Rad	= 90° 00′	10,00000	As Rad	= 90° 00′	10,00000
diſt.	= 768 m.	2,88536	To diſt.	= 768 m.	2,88536
coſ. Cou.	= 33° 45′	9,91985	So ſin. Cou.	= 33° 45′	9,74474
diff. lat.	= 638,6 m.	2,80521	To dep.	= 426,7 m.	2,63010

w 6,0)63,9(10° 39.

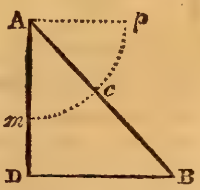
Then Lat. from 3° 25′ S.
diff. lat. 10 39 N.

Anſwer { Lat. in 7 14 N.
Depart. 426,7 miles.

QUEST. II. *Yeſterday noon we were in Lat. 38° 32′ N. and this day at n we are in Lat. 36° 56′ N.; we have run on a direct courſe between S. and E. 5½ knots an hour: Required our courſe and departure?*

at from 38° 32′ N.
at. in 36 56 N.
iff. lat. 1 36 = 96 m.

24 hours.
5,5 = 5½
120
120
Diſt. = 132,0 m.



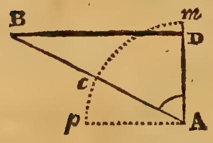
ONST. Deſcribe the quadrant A m p; draw the meridian AD = 96, draw DB parallel to Ap; with 132 m. from A, cut DB in B.

COMPUTATION.

A diſt.	= 132 m.	7,87943	As Rad	= 90° 00′	10,00000
T Rad	= 90° 00′	10,00000	To diſt.	= 132 m.	2,12057
S diff. lat.	= 96 m.	1,98227	So ſin. Cou.	= 43° 20′	9,83648
T coſ. Cou.	= 43° 20′	9,86170	To dep.	= 90,58	1,95705

nſwer { Courſe is S. 43° 20′ E. or SE. b. S. ¾ E. nearly.
Departare 90,58 miles to Eaſtward.

QUEST. III. *A ſhip in Lat.* 3° 52′ *S. is bound to a port bearing N by W.* ½ *W. in Lat.* 4° 30′ *N.: How far does that port lie to the weſtwa and what is the ſhip's diſtance from it?*



Lat. from 3° 52′ S.
Lat. to 4 30 N.

Diff. lat. 8 22
60

502 miles.

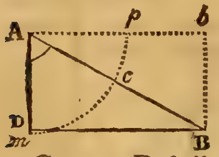
CONST. Deſcribe the quadrant A *m p*: Draw the meridi AD = 502, and thro' D draw DB parallel to A *p*: Make *m c* = points: Thro' *c* draw AB meeting DB in B.

COMPUTATION.

As coſ. Cou.	= 61° 52′	0,32650	As coſ. Cou.	= 61° 52′	0,326
To diff. lat.	= 502 m.	2,70070	To diff. lat.	= 502 m.	2,700
So Rad	= 90° 00′	10,00000	So ſin. Cou.	= 61° 52′	9,945
To diſt.	= 1065	3,02720	To dep.	= 938,9	2,972

Anſwer { The port lies 938,9 m. to the weſtward.
The direct diſtance is 1065.

QUEST. IV. *A ſhip from Lat.* 30° 14′ *N. ſails SE. by E.* ½ *and four days after meets a ſloop who had ſailed directly eaſt at the rate* 6 *miles an hour, ſhe having been four days before under the meridian the departed from: Required the difference of their rate of ſailing, and th preſent latitude?*



As the ſhip and ſloop ſailed from the ſame me dian, and the ſloop runs directly eaſt; theref her diſtance will be the ſhip's departure.
Now in 4 days are 96 hours.
And 96 x 6 = 576 miles of dep.

CONST. Deſcribe the quadrant A *m p*.
In A *p* continued take A *b* = 576, and draw *b* B parallel to A *m*.
Make *m c* = 5½ points, and thro' *c* draw A *c* meeting *b* B in B.
Thro' B draw BD parallel to *b* A meeting A *m* continued in D.

COMPUTATION.

As ſin. Cou.	= 61° 52′	0,05460	As ſin. Cou.	= 61° 52′	0,054
To dep.	= 576 m.	2,76042	To dep.	= 576 m.	2,760
So Rad	= 90° 00′	10,00000	So coſ. Cou.	= 61° 52′	9,673
To diſt.	= 653,2 m.	2,81502	To diff. lat.	= 308 m.	2,488

Now 96)653,2(6,8 m. per hour the [ſhip's rate.
.772

And 6,0)30,8(
5 8

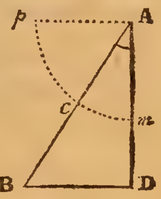
Then Lat. fr. 30° 14′
diff. lat. 5 08
Lat. in 25 06

So the difference of their rate of ſailing is $\frac{8}{10}$ or $\frac{4}{5}$ of a mile per hour.

QUES

QUEST. V. *A ſhip from the Lat. 48° 17′ N. ſails SW. by S. until has depreſſed the north pole two degrees: What direct diſtance has ſhe n, and how many miles is ſhe got to the weſtward?*

To depreſs the pole two degrees, the ſhip muſt ſl ſouthward until her diff. lat. is 2 degrees, or o miles.



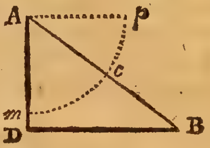
CONST. 1ſt. Draw AD = diff. lat. 120 m.
Deſcribe the quadrant A *m p*, make *m c* = 3 pnts.
3 Thro' *c* draw AB, meeting DB drawn thro' D pallel to A *p*.

COMPUTATION.

coſ. Cou.	= 33° 45′	0,08015	As coſ. Cou.	= 33° 45′	0,08015
T diff. lat.	= 120 m.	2,07918	To diff. lat.	= 120 m.	2,07918
S Rad	= 90° 00′	10,00000	So ſin. Cou.	= 33° 45′	9,74474
T diſt.	= 144,3	2,15933	To dep.	= 80,18	1,90407

nſwer { Ship has run 144,3 miles.
And has got to the weſtward 80,18 miles.

UEST. VI. *Two ports lie under the ſame meridian, one in latitude* 5 30′ *N. and the other in latitude* 47° 10′ *N. A ſhip from the ſouther- ſails due Eaſt* 9 *knots an hour, and two days after meets a ſloop that ſailed from the Northermoſt port: Required the ſloop's direct courſe and nce run?*



ere the diſtance the ſhip ſails Eaſt is the ſloop's derture.

ow 2 days = 48 hours.
hen 48 × 9 = 432 m. = departure.

Sloop's lat.	52° 30′ N.
Ship's lat.	47 10 N.
Diff. lat.	5 20 = 320 m.

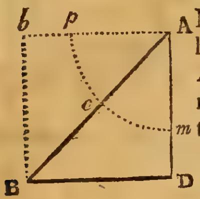
ONST. In the meridian, take AD for the diff. lat. 320 m. and perpelicular to AD draw the departure DB = 432 m. and draw the diſtace AB.

COMPUTATION.

As iff. lat.	= 320 m.	7,49485	As ſin. Cou.	= 53° 28′	0,09501
T dep.	= 432 m.	2,63548	To dep.	= 432 m.	2,63548
So ad	= 45° 00′	10,00000	So Rad	= 90° 00′	10,00000
T an. Cou.	= 53 28	10,13033	To diſt.	= 537,6	2,73049

nſwer { The ſloop has ſailed S. 53° 28′ E. or SE. $\frac{3}{4}$ E.
And has run 537,6 miles.

QUEST. VII. *A ſhip from a port in latitude 38° 25′ S. ſails tween the S. and W. at the rate of $7\frac{1}{2}$ knots an hour; three days a meets a ſloop, who two days before had ſailed from a port under the j meridian the ſhip departed from, and kept on a weſt courſe 8 miles hour: Required the ſhip's direct courſe and preſent latitude?*



Now 3 days is 72 hours, which at $7\frac{1}{2}$ knots hour, makes 540 miles for the ſhip's run. And 2 days is 48 hours, which, at 8 knots an h makes 384 miles for the ſloop's run, and is e to the weſting, or departure of the ſhip.

CONST. Having deſcribed the quadrant A make A b = 384; from A, with 540, cut b B rallel to AD, in B; draw AB, and BD parallel to A p.

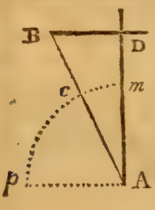
COMPUTATION.

As Diſt.	= 540 m.	7,26761	As Rad	= 90° 00′	10,00
To Rad	= 90° 00′	10,00000	To Diſt.	= 540 m.	2,73
So Dep.	= 384 m.	2,58433	So coſ. Cou.	= 45° 20′	9,84
To ſin. Cou.	= 45° 20′	9,85194	To diff. lat.	= 379,6	2,57

6,0)38,0(6° 20′.
And (38° 25′ + 6° 20′ =) 44° 45′ S.

Anſwer { Courſe S. 45° 20′ W. or
Preſent latitude is 44° 45′

QUEST. VIII. *A brig from a port in latitude 28° 38′ N. ſails due at the rate of $8\frac{1}{2}$ knots an hour; after three days ſhe meets a ſhip who run due W. 342 miles from a port 30 leagues to the eaſtward of the ridian that the brig's crew thought themſelves under; who alſo fo they had not increaſed their latitude by 24 leagues ſo much as by their count: Required the true courſe and diſtance the brig has made?*



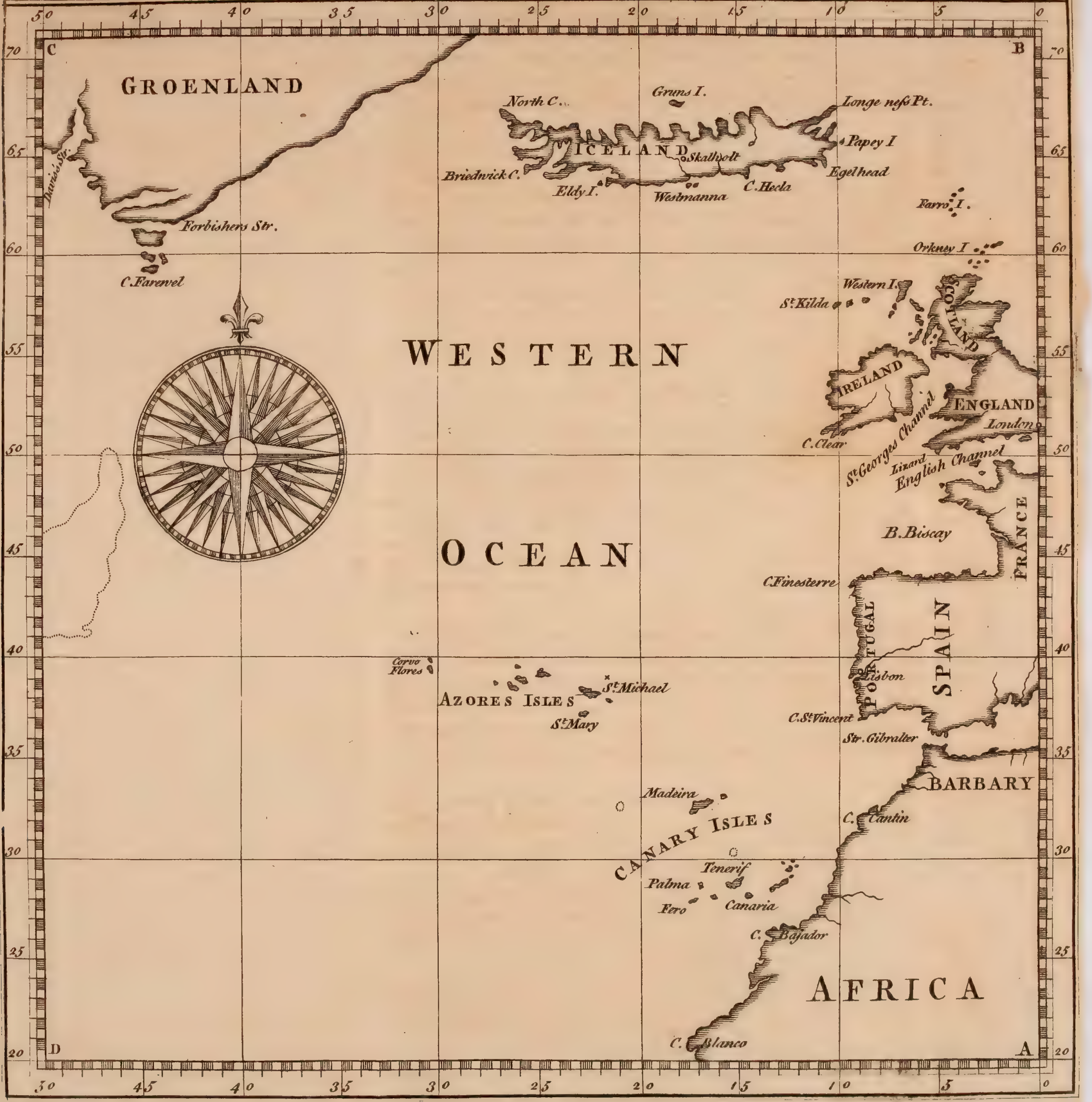
Now $8\frac{1}{2}$ knots an hour for 3 days, is 612 mi for the brig's apparent northing; from which t ing 24 leagues, or 72 m. her error in account, le 540 miles for her true diff. lat.

And as the ſhip's departed meridian is 30 leag or 90 miles to the eaſtward of the brig's; then taken from 342 leaves 252 m. for the weſting fr the brig's meridian.

So that the brig having made 540 m. northing, and 252 m. w ing; her courſe and diſtance, found by the 6th caſe (692), will be
Courſe N. 25° 01′ W. or NNW. ¼ W. nearly.
Diſtance 595,9 miles.

SECTIO

PLANE CHART Pl: II.



J. Jefferys sculp.

Page 252.

SECTION V.

Of compound courſes.

694. A Compound course is an irregular track which a ſhip makes a known time, by ſailing on ſeveral different courſes: Or where vo or more caſes of Plane ſailing are concerned.

A Traverse is a Compound courſe, wherein ſeveral different ſucſſive courſes and diſtances are known.

5. To work a Traverse,

Or, to reduce a compound courſe to a ſingle one.

1ſt. Make a table of ſix columns, title them Courſe, Diſt. N. S. E. . beginning at the left ſide, and write the given courſes and diſtances their reſpective columns.

2d. In the traverſe table (711, 712) ſeek the given courſes and diſnces, and let the correſponding differences of latitude and departures wrote in their proper columns in the table made for the queſtion.

3d. Add up the columns of northing, ſouthing, eaſting, and weſtg; then the difference between the ſums of the northing and ſouthing ves the whole difference of latitude of the ſame name with the greater; d the difference between the ſums of the eaſting and weſting will the whole departure, of the ſame name with the greater.

4th. The whole diff. lat. and departure to the compound courſe being und, the direct courſe and diſtance will be found as in Caſe VI. of gle courſes.

6. To construct a Traverse.

1ſt. Deſcribe a circle with the chord of 60 degrees, and divide it o 4 quadrants; marking the north point with N.

2d. Lay off each courſe on the circumference, reckoned from its per meridian; and from the centre to each point draw ſo many blank lii; mark theſe with the proper number of the courſe.

3d. On the firſt radius, lay the firſt diſtance, mark its extremity; ough this extremity, and parallel to the ſecond radius, draw the ſend diſtance of its proper length; through the extremity of the ſecond tance, and parallel to the third radius, draw the third diſtance of its per length: And thus proceed until all the diſtances are drawn.

4th. A line drawn from the extremity of the laſt diſtance, to centre of the circle, will repreſent the diſtance made good; and a drawn from the ſame point, perpendicular to the meridian (lengthe if neceſſary), will repreſent the departure.

697. When a ſhip from a given place is bound to a known pc and on ſome occaſion ſhe is obliged to run on one or more differ courſes, not in the direct one to the port; and then wants to find direct courſe and diſtance ſhe muſt now run to gain her port, obſe the following precepts.

1ſt. Find the diff. lat. and dep. between the ſhip's firſt place and port bound to.

2d. Find the diff. lat. and dep. between the ſhip's firſt place and place ſhe is come to.

3d. If theſe differences of latitude are both of the ſame name, t their difference for a new diff. lat.: But if of contrary names, t their ſum.

4th. If the departures are both of the ſame name, take their differe for a new departure: But take their ſum if of contrary names.

5th. To this new difference of latitude and departure, find the co and diſtance (692).

6th. If between the place ſailed from and the place come to, th has been more than one courſe: To each courſe let the diff. lat. departure be found; and let their ſum or difference be taken accord as they are of the ſame, or of contrary names; and this will give diff. lat. and departure between the place ſailed from and the pl come to: Then proceed by the 3d, 4th and 5th precepts.

698. To construct a Compound course.

1ſt. Deſcribe a circle, in which draw the meridian and parallel the place ſailed from.

2d. Conſtruct the triangle between the place ſailed from, marked, and the place bound to, marked B; and let the interſection of the lat. and departure be marked D.

3d. Conſtruct the figure between the place ſailed from, or A, the place come to, marked C; and let the interſection of this diff. and departure be marked E.

4th. Through C draw CF parallel to AD, meeting BD, continued neceſſary, in F; and draw CB.

5th. Then in the triangle CFB, the lines CF, FB, CB, will repreſ the diff. lat. departure and diſtance between the place come to, and place bound to.

6th. From the centre A draw a line parallel to CB, in the direct from C to B, and this ſhews the courſe wanted.

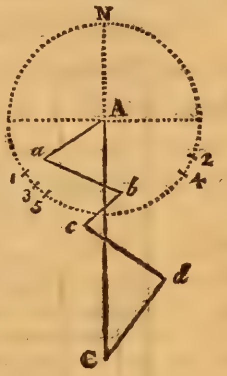
9. *Examples to exerciſe Traverſe ſailing.*

QUESTION I. *A ſhip ſails from a place in latitude* 24° 32′ *N. and s run the following courſes and diſtances, viz.*
1. SW. b. W. diſt. 45 m. 2d. ESE. diſt. 50 m. 3d. SW. diſt. 30 m.
h. SE. b. E. diſt. 60 m. 5th. SW. b. S. ¼ W. diſt. 63 m.
Required her preſent latitude, with the direct courſe and diſtance between place ſailed from, and the place come to?

Conſtruct the traverſe table by art. 695, and the figure by art. 696.

TRAVERSE TABLE.

Courſes.	Dif	N.	S.	E.	W.
V. b. W.	45		25,0		37,4
E.	50		19,1	46,2	
W.	30		21,2		21,2
. b. E.	60		33,3	49,9	
V. b. S. ¼. W.	63		50,6		37,5
			149,2	96,1	96,1



The traverſe table being computed; the ſum of the ſouthings 49,2 miles, and ſo far the ſhip got to the ſouthward, or altered her latitude.

Now 149 miles is 2° 29′
Then Lat. from 24 32 N.
Diff. lat. 2 29 S.

Preſent lat. 22 03 N.

The miles of departure in the column are 96,1; and thoſe in the weſt column are alſo 96,1: as the eaſt and weſt departures directly oppoſite, they deſtroy another, and the ſhip in her preſent ſtation has made no departure; therefore ſhe is under the meridian ſailed from: Conſequently her courſe made good is directly ſouth; and her diſtance is the ſame as the difference of latitude, which is 149,2.

In this figure, the circle which is deſcribed with the chord of 60°, repreſents the horizon, the centre whereof is the place the ſhip ſailed from; thro' which are drawn the two diameters at right angles to one another, the one repreſenting the meridian, the other the parallel of latitude the ſhip departed from: On the circumference is laid the ſeveral courſes, and numbered 1, 2, 3, 4, 5. On the firſt rhumb A 1, is laid the firſt diſtance A *a* = 45; thro' *a*, and parallel to the rhumb A 2, is drawn the ſecond diſtance *a b* = 50; thro' *b*, and parallel to the rhumb A 3, is drawn the third diſtance *b c* = 30; thro' c, and parallel to the rhumb A 4, is drawn the fourth diſtane *c d* = 60; thro' *d*, and parallel to the rhumb A 5, is drawn the fifth diſtance *d* C = 63.

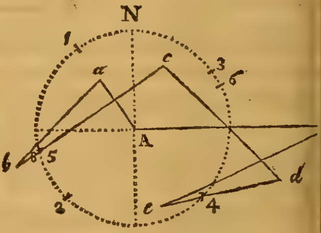
Quest. II. *A ſhip from the latitude 28° 32′ N. has run the follo courſes, viz.*

1ſt. NW.b.N.diſt.20m. 2d. SW. diſt. 40m. 3d. NE. b. E. diſt.6
4th. SE. diſt. 55 m. 5th.W.b.S. diſt. 41 m. 6th. E.NE. diſt. 6

Required her preſent latitude, with the direct courſe and diſtance bet the place ſailed from and the place come to?

Conſtruct the traverſe table by art. 695, and the figure by art. 6

Traverse Table.					
Courſes.	Dif	N.	S.	E.	W.
NW. b. N.	20	16,6			11,1
SW.	40		28,3		28,3
NE. b. E.	60	33,3		49,9	
SE.	55		38,9	38,9	
W. b. S.	41		8,0		40,2
ENE.	66	25,3		61,0	
		75,2	75,2	149,8	79,6
				79,6	
				70,2	Dep.



The traverſe table being filled up, the ſum of the northings and ſouthings are both 75,2 miles; which being of contrary directions, ſhew that the ſhip has returned to the ſame parallel of latitude failed from.

The ſum of the eaſtings is 149,8, and that of the weſtings is 79,6; their difference 70,2 ſhews that the ſhip has gained ſo much to the eaſtward, that being greateſt.

Here A is the place ſailed fr and C is the place the ſhip is c to, by ſailing along the lines *a b*, *b c*, *c d*, *d e*, *e* C.

The diſtance ſhe has got A, is repreſented by AC; w alſo expreſſes the rhumb bet A and C.

Conſequently the courſe made good is due Eaſt.

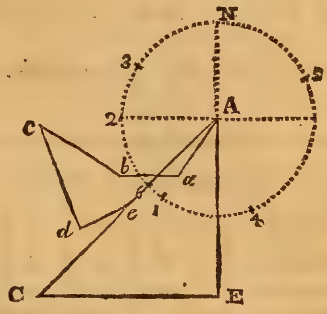
And the diſtance is 70,2 miles.

Qu

QUEST. III. *Since yeſterday noon we have run the following courſes:*
1ſt. SW. b. S. 20 m. 2d. W. 16 m. 3d. NW. b. W. 28 m.
4th. SSE. 32 m. 5th. ENE. 14 m. 6th. SW. 36 m.
Vhat diff. lat. and departure has the ſhip made, and what is her direct rſe and diſtance?

TRAVERSE TABLE.

Courſes.	D.	N.	S.	E.	W.
W. b. S.	20		16,6		11,1
.	16				16,0
W. b. W.	28	15,6			23,3
E.	32		29,6	12,3	
NE.	14	5,4		12,9	
W.	36		25,5		25,5
		21,0	71,7	25,2	75,9
			21,0		25,2
		D.lat.	50,7	Dep.	50,7



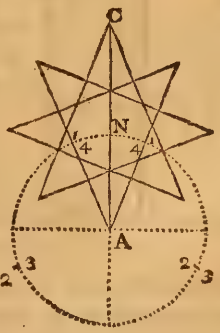
As the D. lat. and Dep. are equal, the courſe is S. 45° W. or SW.
l, As ſ.∠A : CE : : ſ.∠E : AC. Or ſ. 45° 00′ : 50,7 m. : : ſ. 90° 00′ : 71,7 m.

QUEST. IV. *Two ſhips,* A *and* B, *part company in lat.* 31° 31′ *N. and t together again at the end of two days, having run as follows:*
A 1ſt. NNE. 96 m. 2d. WSW. 96 m. 3d. ESE. 96 m. 4th. NNW. 96 m.
B 1ſt. NNW. 96 m. 2d. ESE. 96 m. 3d. WSW 96 m. 4th. NNE. 96 m.
Required the lat. arrived in, with the direct courſe and diſt. of each ſhip?

As the courſes ſteered by both ſhips are equally diſtant from the idian; therefore one traverſe will ſerve for both.

TRAVERSE TABLE.

Courſes.	D.	N.	S.	E.	W.
NE.	96	88,7		36,7	
SW.	96		36,7		88,7
E.	96		36,7	88,7	
NW.	96	88,7			36,7
		177,4	73,4	125,4	125,4
		73,4			
		104,0	D.lat.		



There being no departure, and the diff. lat. being N.
Therefore the courſe made good is N. and the diſtance is 104 miles.
The lat. arrived in is 33° 15′ N.

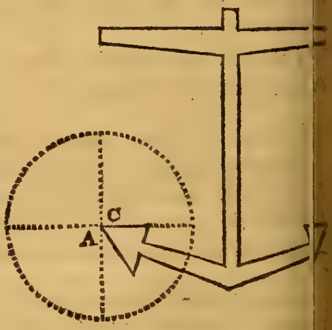
Quest. V. *Suppoſe a ſhip from the lat. of* 40° 00′ *N. ſails as follo*

1ſt. SE. b. S.	29 m.	2d. NNE.	10 m.	3d. ESE.	5
4th. ENE.	50 m.	5th. SSE.	10 m.	6th. NE. b. N.	2
7th. Weſt	25 m.	8th. SSE.	10 m.	9th. WSW. ½ W.	4
10th. North	110 m.	11th. E. ¾ N.	62 m.	12th. North	7
13th. Weſt	62 m.	14th. North	10 m.	15th. Weſt	8
16th. South	10 m.	17th. Weſt	62 m.	18th. South	
19th. E. ¾ S.	62 m.	20th. South	110 m.	21ſt. WNW. ½ W.	4
22d. NNE.	10 m.	23d. Weſt	25 m.		

Required the ſhip's place, with the direct courſe and diſtance?

TRAVERSE TABLE.

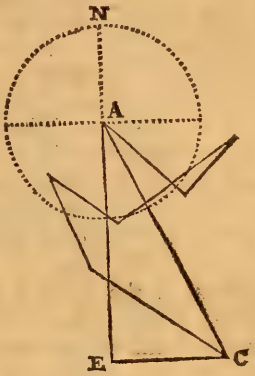
Courſes.	D.	N.	S.	E.	W.
SE. b. S.	29		24,1	16,1	
NNE.	10	9,2		3,8	
ESE.	50		19,1	46,2	
ENE.	50	19,1		46,2	
SSE.	10		9,2	3,8	
NE. b. N.	29	24,1		16,1	
Weſt	25				25,0
SSE.	10		9,2	3,8	
WSW. ½ W.	42		12,2		40,2
North	110	110,			
E. ¾ N.	62	9,1		61,3	
North	7	7,0			
Weſt	62				62,0
North	10	10,0			
Weſt	8				8,0
South	10		10,0		
Weſt	62				62,0
South	7		7,0		
E. ¾ S.	62		9,1	61,3	
South	110		110,0		
WNW. ½ W.	42	12,2			40,2
NNE.	10	9,2		3,8	
Weſt	25				25,0
		209,	209,9	262,4	262,4



As the difference of latitude and departures are equal; therefor ſhip is returned to the place ſhe ſailed from.

QUEST. VI. *The laſt 24 hours we have run the following courſes, viz.*
ſt. SE. 40 m. 2d. NE. 28 m. 3d. SW. b. W. 52 m.
th. NW. b.W. 30 m. 5th. SSE. 36 m. 6th. SE. b. E. 58 m.
Required the preſent latitude, departure, direct courſe and diſtance?

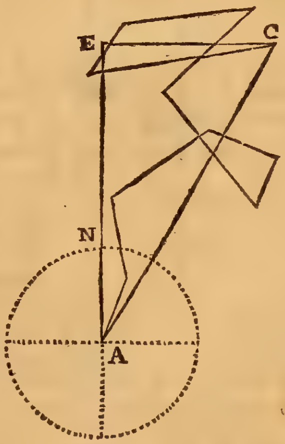
TRAVERSE TABLE.					
Courſes.	D.	N.	S.	E.	W.
E.	40		28,3	28,3	
E.	28	19,8		19,8	
W. b. W.	52		28,9		43,2
W. b. W.	30	16,7			24,9
E.	36		33,3	13,8	
b. E.	58		32,2	48,2	
		36,5	122,7	110,1	68,1
			36,5	68,1	
		D.lat.	86,2	42,0	Dep



the courſe. As 86,2 m. : 42 m. :: Rad : t. 25° 59′. Or SSE.¼E. nearly.
the diſtance. As ſ. 25° 59′ : 42 m. : : Rad : 95,87 m.

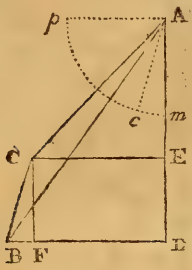
QUEST. VII. *Yeſterday noon we were in lat.* 3° 18′ *S. and ſince then we* *e plied on the following courſes, viz.*
t. NNE. 22 m. 2d. N. b. W. 30 m. 3d. NE. b. E. 40 m.
h. ESE. 25 m. 5th. SSW. 18 m. 6th. NW. b. N. ½W. 50 m.
h. NE.½E. 42 m. 8th. W.b.S.½W. 45 m. 9th. SW. b. S. 20 m.
h. E. b. N. ¼E. 62 m. *Required our preſent lat. and departure, with* *courſe and diſtance made good?*

TRAVERSE TABLE.					
ourſes.	D.	N.	S.	E.	W.
NE.	22	20,3		8,4	
b. W.	30	29,4			5,8
E. b. E.	40	22,2		33,3	
E.	25		9,6	23,1	
W.	18		16,6		6,8
.b.N.½W.	50	38,6			31,7
E. ½ E.	42	26,6		32,5	
b.S.½W.	45		4,4		44,8
V. b. S.	20		16,6		11,1
b. N.¼E.	62	9,1		61,3	
		146,2	47,2	158,6	100,2
		47,2		100,2	
		99,0	D lat	58,4	Dep



r the courſe. As 99 m. : 58,4 m. : : Rad : t. 30° 32′. Or NNE.¾E.
r the diſt. As ſ. 30° 32′ : 58,4 m. : : Rad : 115 the diſtance.

Quest. VIII. *Yeſterday noon we were in lat.* 33° 15′ *N. and boun a port in lat.* 28° 35′ *N. lying* 196 *miles to the weſt; and this day at n we are in lat.* 30° 20′ *N. having made* 168 *miles of weſting: Required direct courſe and diſtance to our intended port?*



Lat. from	33° 15′ N.	Lat. from	33° 15′ N.
Lat. to	28 35 N.	Lat. in	30 20 N.
Diff. lat.	4 40 = 280 m.	Diff. lat.	2 55 = 1

The figure is conſtructed by art. 698.

Thus. In the meridian take AD = 280, AE 175; in DB, EC, drawn parallel to the parallel lat. A *p*, take BD = 196, EC = 168; draw AB, CB; and draw CF parallel to AD, and A *c* paralle CB.

Then A is the place ſailed from; C the place come to; B the pl bound to; CB the diſtance the ſhip has to ſail; and the arc *mc* meaſu the angle of the courſe ſhe muſt ſail on.

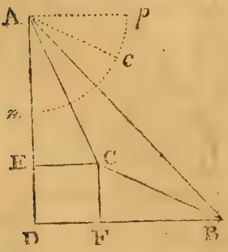
From AD	=	280	From DB	=	196
Take AE	=	175	Take CE = FD	=	168
Leaves ED = CF	=	105	Leaves BF	=	28

In the triangle CFB.

To find the Courſe.			To find the diſtance.		
As CF, diff. lat.	=105	7,97881	As ſin. Cou.	= 14° 55′	0,58
To BF, dep.	= 28	1,44715	To Dep.	= 28 m.	1,44
So Rad	= 45° 00′	10,00000	So Rad	= 90 00	10,00
To t. ∠BCF, t.Co.	= 14 55	9,42596	To Diſt.	= 108,8	2,03

Anſwer: Courſe is S. 14° 15′ W. or S. b. W. ¼ W. Diſt. 108,8 miles.

Quest. IX. *A ſhip from latitude* 14° 25′ *N. and bound to a por latitude* 5° 18′ *N. lying* 476 *miles to the eaſtward; finds ſhe has made miles of ſouthing, and* 150 *of eaſting: Required the courſe and diſtance has to ſail, to reach her intended port?*



The figure is conſtructed by art. 698.

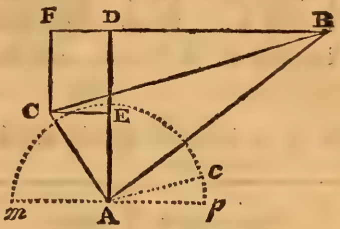
Lat. from	14° 25′ N.
Lat. to	5 18 N.
Diff. lat.	9 07 = 547 miles.

AD	=	547	DB	=	
AE	=	400	EC = DF	=	
ED = CF	=	147	FB	=	

Then CF : FB :: Rad : t. ∠BCF. Or 147 : 326 :: t. 45° : t. 65°
And ſ. ∠FCB : FB :: Rad : CB. Or ſ. 65° 44′ : 326 :: ſ. 90° : 35
Anſwer. Courſe is S. 65° 44′ E.; or SE. b. E. ¾ E. Diſtance 357,6

QUEST. X. *Four days ago we were in lat.* 4° 39′ *S. long.* 83° 16′ *E. London; and now we are in lat.* 0° 35′ *N. having made* 200 *miles of ſting: Required our preſent courſe and diſtance to Achen in the Iſland of matra?*

The fig. is conſtructed by art. 698.



Lat. from 4° 39′ S.
Lat. to 5 15 N.

Diff. lat. 9 54 = 594 miles.

Lat. from 4° 39′ S.
Lat. in 0 35 N.

Diff. lat. 5 14 = 314 m.

Long. from 83° 16′ E.
Long. to 95 55 E.

Diff. long. 12 39 = 759 miles.

AD = 594
AE = 314

ED = 280 = CF.

DB = 759
FD = 200 = CE

FB = 959.

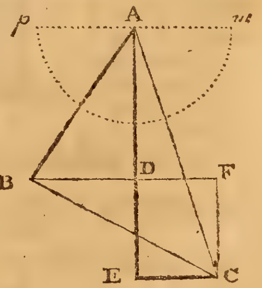
In the triangle CFB, to find the courſe and diſtance.

s CF : FB :: Rad : t.∠FCB. Or 280 : 959 :: t.45° 00′ : t.73° 43′.
ſ.∠FCB : FB :: Rad : CB. Or ſ. 73° 43′ : 959 :: ſ. 90° 00′ : 999.

Anſwer { The courſe is N. 73° 43′ E. or ENE. ½ E.
The diſtance is 999 miles.

QUEST. XI. *A ſhip from the lat.* 10° 38′ *N. and bound to a port lying* 2 *miles to SW. b. S. after three ſucceſſive days of bad weather, finds herſ in lat.* 3° 58′ *N. and* 120 *miles to the eaſtward: Required her preſent rſe and diſtance to her intended port?*

The figure is conſtructed by art. 698.



In the triangle ABD, find AD and BD.

As Rad : AB :: ſ. ∠ B : AD.
Or Rad : 282 :: ſ. 56° 15′ : 234,5.
And Rad : AB :: ſ. ∠ BAD : BD.
Or Rad : 282 :: ſ. 33° 45′ : 156,6.

Lat. from 10° 38′ N.
Lat. in 3 58 N.

Diff. lat. 6 40 = 400 m.

AE = 400
AD = 234,5

DE = CF = 165,5

BD = 156,6
EC = DF = 120

BF = 276,6

In the triangle CFB find the courſe and diſtance.

s CF : FB :: R : t.∠FCB. Or 165,5 : 276,6 :: Rad : t. 59° 06′.
s ſ. ∠ FCB : FB :: R : CB. Or ſ.59°6′ : 276,6 :: Rad : 322,4.

Anſwer { Courſe is N. 59° 06′ W. Or NW. b. W. ¼ W.
Diſtance is 322,4 miles.

Quest. XII. *A ſhip in the lat.* 17° 10′ *N. is bound to a port in* *lat.* 13° 10′ *N. the departure being* 180 *miles weſtward; ſails theſe cou*

1ſt. SW. b. W. 27 m. 2d. WSW. ½ W. 30 m. 3d. W. b. S. 25
4th. W. b. N. 18 m. 5th. SSE. 32 m. 6th. SSE. ¾ E. 27
7th. S. b. E. 25 m. 8th. South 31 m. 9th. SSE. 39

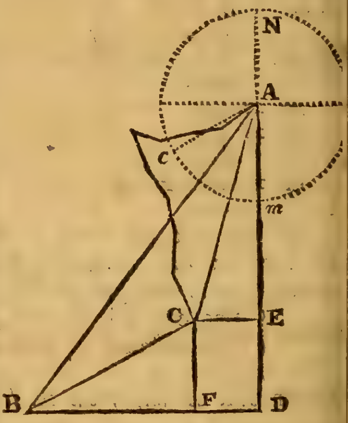
Required her preſent lat. and the direct courſe and diſtance to the de port?

The figure is conſtructed by art. 698.

Depart. lat. 17° 10′ N.
Lat. bound to 13 10 N.
Diff. lat. 4 00 = 240

Traverse Table.

Courſes.	D.	N.	S.	E.	W.
SW. b. W.	27		15,0		22,4
WSW. ½ W.	30		8,7		28,7
W. b. S.	25		4,9		24,5
W. b. N.	18	3,6			17,7
SSE.	32		29,6	12,2	
SSE. ¾ E.	27		23,1	13,9	
S. b. E.	25		24,5	4,9	
South	31		31,0		
SSE.	39		36,0	14,9	
		3,6	172,8	45,9	93,3
			3,6		45,9
		D. la.	169,2	Dep.	47,4



Now 17° 10′ N. = Dep. lat.
60)169(2 49 S. = Diff. lat.
14 21 N. = Preſ. lat.

And AD = 240,0
AE = 169,2
CF = ED = 70,8

Alſo BD = 180,0
CE = 47,4 =
BF = 132,6

In the triangle CFB;

To find the courſe. CF : FB : : Rad : t. ∠ FCB.
Or, 70,8 : 132,6 : : Rad : t. 61° 54′.

To find the diſtance. ſ. ∠ FCB : FB : : Rad : CB.
Or, ſ. 61° 54′ : 132,6 : : Rad : 150,3.

Anſwer { The preſent latitude is 14° 21′ N.
Courſe is S. 61° 54′ W. or SW. b. W. ½
Diſtance is 150,3 miles.

In this queſtion A is the place the ſhip ſails from.
B is the place ſhe is bound to.
C is the place come to by the traverſe.
And CB is the rhumb ſhe muſt ſail on to come to B.

Que

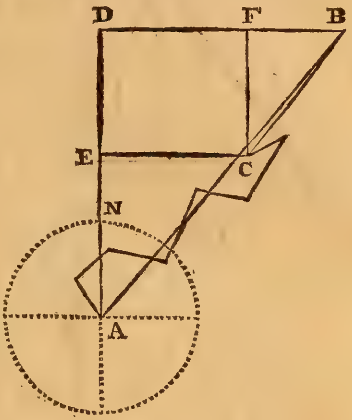
QUEST. XIII. *Yeſterday noon we were in latitude 0° 15′ S. and bound to port bearing NE. b. N. ½ E. in latitude 2° 15′ N.; by the log we have n the following courſes, viz.*

NW. 25 m. NE. b. E. 28 m. E. b. S. ¼ E. 32 m. NNE. 41 m.
SE. ½ E. 24 m. NE. b. N. 39 m. WSW. 24 m.

Required the ſhip's place, with the direct courſe and diſtance to the in-
ıded port?

The diff. lat. AD = 150 m.

In the triangle ADB, the departure
will be found to be 123 m.
In the traverſe, the diff. lat. AE =
,6; and the departure EC = 75,4
les.
In the triangle CFB, where CF
67,4; FB = 47,5; the courſe is
35° 14′ E. or NE. b. N. ¼ E.;
the diſtance is 82,51 miles.

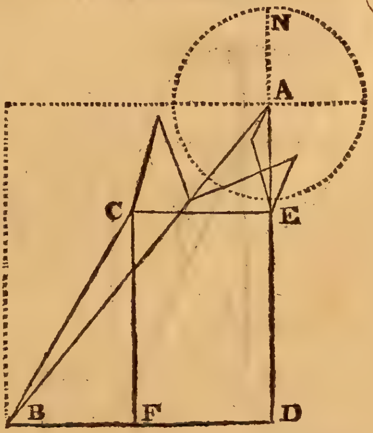


QUEST. XIV. *A ſhip from the latitude of 18° 14′ N. is bound to a*
t bearing SW. b. S. ½ W. and 138 miles to the weſtward; having ſailed
following courſes, viz.

SSW. 22 m. S. b. E. ½ E. 38 m. NNE. 30 m. WSW. 57 m.
NNW 45 m. S. b. W. ½ W. 50 m.

Required the ſhip's place, with the direct courſe and diſtance to the deſired
t?

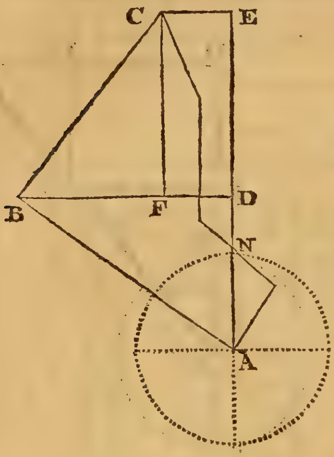
n the triangle ADB, the diff. lat.
, will be found to be 168,2 miles.
n the traverſe, the diff. lat. AE
= 57 m. and the departure CE =
73 m.
n the triangle CFB, where CF =
,2; FB = 67,7;
The courſe is S. 31° 20′ W. or
SW. ¾ W.
The diſtance is 130,2 miles.



QUEST. XV. *A ſhip in the lat. of 1° 00′ S. is bound to a port in 1° 10′ N. diſtant 220 miles in the NW. quarter; and meeting with c trary winds, runs the following courſes, viz.*

NE. by N. 63 m. NW. $\frac{1}{4}$ W. 85 m. North 96 m. NNW. 87

Required the ſhip's place, and the courſe and diſtance to her port?



In the triangle ADB, the co DAB will be found = 53° 47′; the departure DB = 177,5 miles.

In the traverſe, the difference lat. AE = 285,9.

The depart. EC = 61,3.

In the triangle CFB.

Where CF = (AE — AD =) 15

BF = (DB — CE =) 11

The courſe FCB = 36° 42′.

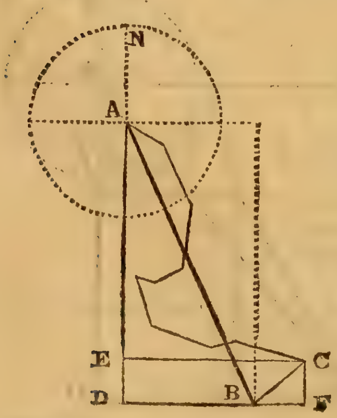
The diſt. CB = 194,4.

Anſwer { The preſ. lat. 3° 46′
The courſe SW. b.S. $\frac{1}{4}$
Diſtance 194,4 m.

QUEST. XVI. *A ſhip in the lat. of 1° 36′ N. is bound to a port l to the S. eaſtward, diſtant 420 miles, and 180 miles to the eaſtward; having plied on the following courſes, viz.*

SE. b. E. 59 m. SSE. $\frac{1}{2}$ E. 84 m. S. $\frac{1}{4}$ W. 92 m. WSW. 4
W. b. N. 25 m. S. b. E. $\frac{1}{2}$ E. 62 m. ESE. 89 m. E. b. N. 37
ESE. $\frac{1}{2}$ E. 95 m.

Deſires to know her place, and the direct courſe and diſtance to her po?



In the triangle ADB.

The courſe is S. 25° 23′ E.

The diff. lat. AD = 379,5.

In the traverſe AEC.

The diff. lat. AE = 324,2.

The depart. EC = 247,4.

The preſ. lat. is 3° 48′ S.

In the triangle CFB.

The diff. lat. CF = 55,3.

Depart. FB = 67,4.

Courſe is S. 50° 38′ W.

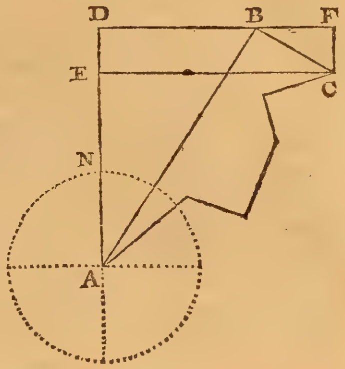
Or SW. $\frac{1}{2}$ W.

The diſtance CB = 87,18 miles.

QUE

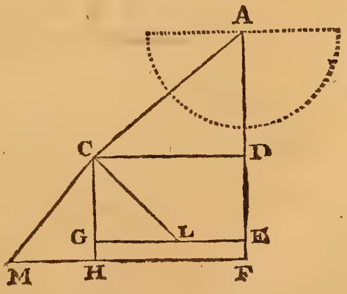
Quest. XVII. *A ſhip from the latitude of* 4° 10′ *N. being to make an* *and that bears NE. b. N. diſtant* 196 *miles; having run theſe courſes, viz.* E. ½ E. 75 m. ESE. ¼ E. 42 m. NNE. ¼ E. 52 m. N. b. W. 34 m. NE. ½ E. 49 m. *Deſires to know her preſent latitude, with her direct* *rſe and diſtance to the Iſland?*

In the triangle ADB.
The diff. lat. AD = 163.
The depart. DB = 108,9.
In the traverſe AEC.
The diff. lat. AE = 128.
The depart. EC = 160.
And the preſent lat. is 6° 18′ N.
In the triangle CFB.
The diff. lat. CF = 35.
The depart. FB = 51,1.
The courſe is N. 55° 36′ W.
Or NW. b. W. nearly.
The diſtance CB = 61,93 miles.

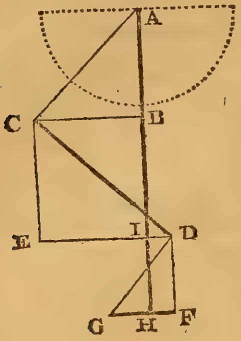


Quest. XVIII. *Two ſhips take their departure from the Lizard in* 49° 57′ *N.; one bound to St. Michael's, which lies* 715 *m. to the S.* 745 *m. to the weſt; the other bound to Liſbon, lying* 661 *m. to the S.* 215 *m. weſt, reckoning from the Lizard: They ſail in company SW.* 610 *miles, and then part: What is the direct courſe and diſtance of* *ſhip to her port?*

In the triangle ADC.
he diff. lat. AD = 387 m.
he depart. DC = 471,5 m.
n the triangle CGL.
he courſe is S. 43° 07′ E.
r SE. b. S. ¾ E. nearly.
he diſtance CL = 375,3 m.
the triangle CHM.
he courſe is S. 39° 49′ W.
r SW. b. S. ½ W. nearly.
he diſtance CM = 427,1 m.

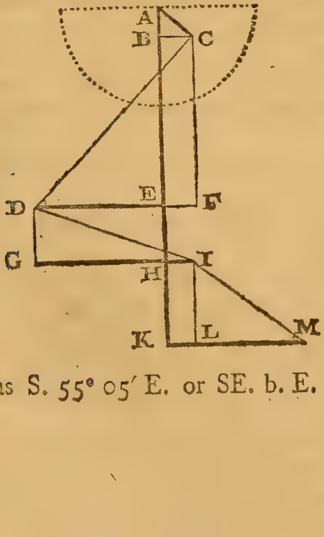


QUEST. XIX. *A ſhip in lat. 43° 20′ N. long. 15° 10′ W. is boun*
St. Michael's, bearing S. 46° 16′ W. in the lat. 38° 13′ N.; and
thence ſhe is bound to Madeira in lat. 32° 25′ N. and diſtant from
Michael's 514 m. in the SE. quarter: Required the diſtance to St. Micha
the courſe from thence to Madeira, together with the courſe and diſtance
Madeira to the Iſland of Palma in lat. 28° 35′ N. long. 17° 13′ W.



In the triangle ABC.
The diſtance to St. Michael's, AC, = 444,
The departure BC = 320,9 m.
In the triangle CED.
The courſe from St. Michael's to Madei
S. 47° 23′ E. or SE. ¼ E. nearly.
The depart. ED = 378,2 m.
In the triangle DFG.
The courſe from Madeira to Palma is S.
05′ W. or SW. b. S. ½ W. nearly.
The diſtance DG = 292,3 m.

QUEST. XX. *Departing from St. Mary's, one of the Azores, and*
to the river Sierra leone, after running SE. 36 hours at 7 knots an
my ſea compaſs was ſpoiled by a flaſh of lightning; then after 8 days
run between the S. and W. I met a ſhip in lat. 20° 00′ N. long. 36° 1
and bound to Mayo, one of the Cape Verd Iſles, to which I ſailed i
company: Required my courſe and diſtance in the 8 days run; alſo the
while I ſailed in company; and the ſame, from Mayo to Sierra leone?



In the triangle ABC.
The diff. lat. = depart. or A
BC = 178,2 m.
In the triangle CFD.
The courſe was S. 49° 07′
or SW. ½ W. nearly.
The diſtance CD = 1286 m
In the triangle DGI.
The courſe to Mayo at I,
S. 71° 51′ E. or ESE. ½ E. ne
The diſtance DI = 901,8 m.
In the triangle ILM.
The courſe to Sierra leone
was S. 55° 05′ E. or SE. b. E. nearly; and the diſt. IM = 682,

SECTI

SECTION VI.

Of oblique ſailing.

o. In the preceding ſections, the bearing and diſtances of places were ermined by the ſolution of right angled triangles: But at ſea there ng many caſes wherein only oblique poſitions can be obſerved, theree 'tis neceſſary to ſhew how ſuch caſes are to be ſolved; which will amply illuſtrated in this, and ſome of the following ſections.

To ſet an object, is to obſerve what rhumb or point of the nautical npaſs is directed to it.

The bearing of an object, is the rhumb on which it is ſeen: And the ıring of one place from another is reckoned by the name of the rhumb ſing thro' thoſe two places.

In every figure relating to any caſe of plane ſailing; the bearing of a e, not running from the centre of the circle or horizon, is found by wing a line parallel thereto, from the centre, and towards the ſame ırter.

The figures belonging to the queſtions in this ſection are in Plate III. he end, wherein the figures are referred to by the number of the ſtion.

QUESTION I. *Two ſhips,* A *and* B, *ſail from two Iſlands bearing the from the other NE. and SW. their diſtance being* 76 *miles;* A *ſails S. E. and* B *runs E. b. S. at laſt they meet: How far has each ſailed?*

CONSTRUCTION. With the chord of 60° deſcribe a circle repreing the horizon of one of the places ſailed from, ſuppoſe of A, the thern; draw the meridian NS, and at right angles to it draw the parel EW.

n this circle lay off the *SW.* rhumb S *o*, the *S. b. E.* rhumb S *p*, and *E. b. S.* rhumb S *m*: Thro' *o* draw AB equal to 76 miles.

Thro' B draw BC parallel to A *m*, meeting AC drawn thro' *p*.

Then A and B repreſent the places ſailed from; AC and BC the diſtances courſes (when properly compared with the meridian) the ſhips had ed when they met at C.

The diſtances AC, BC, may be meaſured from the ſcale AB was taken m.

COMPUTATION. In the triangle ABC there is given one ſide AB, all the angles, to find the other ſides.

Thus, $\angle A = 5$ pts. $= 56° 15'$. For S *o* and S *p* make 5 pts. meaſ. $\angle A$.
$\angle B = 5$ pts. $= 56\ 15$. For BC is paral. A *m*; and $\angle B = \angle BAn$ (185) $= 5$ pts.
$\angle C = 6$ pts. $= 67\ 30$. For BC is paral. A *m*; and $\angle C = \angle CAm$ (185) $= 6$ pts.

Therefore the ſolution belongs to Prob. I. (340).

nd ſ.$\angle C$: AB :: ſ.$\angle A$: BC. Or, As ſ. 67° 30′ : 76 m. :: ſ. 56° 15′ : 68,4 m.

ow as $\angle B = \angle A$: Therefore AC is equal to BC. (194)

nſwer { A ſails S. b. E. 68,4 miles.
B ſails E. b. S. 68,4 miles.

QUESTION II. *Coaſting along ſhore, a headland bore NE. b. N.; t having run E. b. N. 15 miles, the headland bore WNW.: Required diſtance from the headland at each time of ſetting?*

The conſtruction and computation of this queſtion is made as queſt. I.; C being the headland, and AB the ſhip's run.

Anſwer, the diſtance is { 8,496 m. at firſt ſetting.
10,81 m. at ſecond ſetting.

QUESTION III. *In doubling a cape, I obſerved a caſtle up a river l due N.; then running NW. 6 miles, the caſtle bore NNE.: Required diſtance from the caſtle at each time of ſetting it?*

Here C is the caſtle, and AB the ſhip's run.

Anſwer, the caſtle's diſtance at { firſt is $AC = 14{,}48$ m.
laſt is $BC = 11{,}08$ m.

QUESTION IV. *At noon a headland bore NW. b. W.; then ſai NNE. 5 miles an hour, we anchored at 9 in the evening in a creek 18 leag diſtant from the headland: Required its diſtance at noon, and bearing f the creek?*

CONSTRUCTION. Having deſcribed the horizon and drawn the ridian and parallel, in the meridian take any point A for the ſhip's p at firſt: Draw the NW. b. W. and NNE. rhumbs, and parallel to th draw AB, AC.

Make $AC = 45$ m. ($= 9$ h. $\times 5$ m.): And from C with 54 m. ($=$ 1 $\times 3$) cut AB in B. Then B is the headland, and C the creek.

COMPUTATION. Here is given the ſide $AC = 45$ m.; the ſide $= 54$ m. and the $\angle A = 78° 45' = 5$ pts for NW. b. W, $+$ 2 pts. NNE.

Therefore the ſolution falls under Prob. I. (340)

And $\angle B = 54° 49'$; therefore $\angle C = 46° 26'$; and $AB = 39{,}9$ m

Draw ao parallel to CB; then $\angle CBA = \angle oan = 54° 49'$.

Therefore $\angle oan - \angle naw = \angle oaw = 21° 04'$; which taken f 90° 00′ leaves 68° 56′

Anſwer, the headland's { diſtance at noon is 39,9 miles.
bearing from the creek is S. 68° 56′ W
WSW. $\frac{1}{4}$ W. ne

QUESTION V. *A ſhip after ſailing SE. b. S. 62 leagues from her in lat. 29° 16′ N. meets a ſloop that had run 124 leagues from a place l ing W. b. N. of the port the ſhip departed from: What was the ſ courſe, and the diſtance of the two ports?*

The conſtruction and computation being made as in the laſt, A B repreſent the ports ſailed from; and C the place where the veſſels m

Anſwer { The diſtance of the ports is 72,18 miles.
The ſloop's courſe along CB is S. 58° 03′ E. or SE. b. E. ne

QUEST

QUESTION VI. *A merchant ſhip meeting with a ſhip of war, who had led SE. b. E. 39 leagues from the latitude of 45° 30′ N. informed them at he had been plundered the day before in the ſame latitude; and had ce run 67 leagues on a direct courſe between the ſouth and weſt; and that the rates were cruiſing about the place where they robbed him: What courſe ſt the man of war ſteer to come up with them?*

Suppoſe A the place the man of war ſailed from, B the place where e merchant man was robbed, C the place where they met; then the an of war muſt ſail along CB to meet the pyrates; which courſe will ſhewn by *cn* drawn parallel to CB.

Here the given diſtance AC is not drawn from the centre of the circle preſenting the horizon, but parallel to *co* the given courſe; this was ne, in order to prevent the figure from being ſo ſmall as it muſt other-ſe have been.

Here are given two ſides and an angle oppoſite to one of them, to d the angle B oppoſite to the other ſide AC.

Then CB : ſ.∠A :: AC : ſ.∠B. That is, As 67 l. : 33° 45′ :: 39 l. : 18° 52′.

ANSWER. The courſe the man of war muſt ſteer is N. 71° 08′ E.

For ∠*nc*B = ∠CB*c* (185); and 90° — ∠*nc*B = ∠N*cn*.

QUESTION VII. *Two ſhips ſail at the ſame time from one port; one ls ESE. and the other SSE.: Required their bearing and diſtance when ch has run 37½ miles?*

Here, AB = AC; therefore ∠B = ∠C. Now ∠A = 4 pts.; then C = ∠B = 6 pts.

ANSWER. B bears from C N. 45° E. diſtant 67,12 miles.

QUESTION VIII. *Sailing on a SW. courſe at the rate of 4½ miles an ur, at 9 o'clock in the forenoon a cape bore SE. b. E. diſtant 15 miles: equired its bearing and diſtance at 4 o'clock in the afternoon?*

ANSWER. The cape B bears N. 68,08 E. diſtant 37,44 miles.

Here the ſhip is at A at 9 o'clock, and at C at 4 o'clock: The two ſides C, AB, and the contained angle A = 9 pts. are given, to find the reſt.

QUESTION IX. *Wanting to know the breadth of a river in whoſe uth are ſeveral iſlands; from a cliff on the eaſtern ſide, I ſailed NNW. miles; and then running SSW. 35 miles, I reached the weſtern ſhore: equired the breadth between thoſe places?*

Here, AB = 50 m. BC = 35 m. and ∠B = 4 pts. Required AC.

ANSWER. The breadth between A and C is 35,35 miles.

QUESTION X. *From two ports lying under the ſame meridian a diſtant 236 miles, two ſhips ſail towards the eaſt, and meet when ea has run 372 miles: Required the courſe of each?*

In Fig. X. A and B are the ports ſailed from, and C the place wh the ſhips met. Here are given the three ſides; but two of them bei equal, the ſolution is eaſily found by drawing the perpendicular CD. (34

ANSWER. A's courſe is S. 71° 30′ E. and B's courſe N. 71° 30′ E.

QUESTION XI. *Two ſhips meeting at ſea, find they had ſailed fr two ports in the ſame latitude, and diſtant 576 miles: The ſhip from weſtern port had run between the N. and E. 328 miles, and the other h ſailed 416 miles: Required the courſe ſteered by each ſhip?*

A and B are the ports ſailed from, and C the place where the ſhips m From the three given ſides, the angles may be found by art. 344 or 34

ANSWER. The courſe from A is N. 44° 49′ E. and from B is N. 55° 59′

QUESTION XII. *A ſloop in three days coaſted round a triangular ſha iſland; the firſt day ſhe ranged along one ſide, and her courſes reduced to was SW. diſtance 64 miles; the ſecond day's diſtance was 106 miles betw the S. and E.; and that of the third day was 83 miles: Required the dir courſes of the ſecond and third days?*

In Fig. XII. the firſt day's diſtance is AB, the ſecond BC, the third A And the figure is thus conſtructed.

Having deſcribed the horizon, and drawn the meridian and paral (681), their interſection A is taken for the place the ſhip ſailed fro draw the SW. rhumb AB = 64 miles; from A and B deſcribe arcs wi the radii 106 and 83; to their interſection C, draw the lines BC, AC.

Draw the line A *r* parallel to BC, and continue CA to *o*.

Then the arc S *r* meaſures or gives the ſecond day's courſe.

And the arc N *o* the courſe of the third day.

Now the angles being found by either method, as in art. 357; t courſes will be thus obtained.

From $\angle BAC$ take 4 pts. = $\angle SAB$, leaves $\angle SAC$.

Then arc S *r*, or $\angle SAr = \angle SAC + \angle C$ (= $\angle CAr$ by 185) for t ſecond courſe.

And arc N *o*, or $\angle NAo = \angle SAC$ (183) is the 3d day's courſe.

ANSWER. The ſecond day's courſe is S. 83° 29′ E. and the third da N. 46° 21′ W.

The directions given for this 12th queſtion may be applied to t two preceding ones.

QUESTI

Question XIII. *Sailing into a harbour I obſerved two landmarks, the ie bore E. the other W.; and after running S. 3,3 miles, the eaſtern one re N. 58° 30′ E. and the weſtern one N. 47° 20′ W.: Required my iſtance from thoſe landmarks at each time of ſetting them?*

The ſhip is ſuppoſed firſt at A, and ſees the landmarks C and D in ie lines AC, AD; then ſailing to B, ſhe ſees the ſame marks in the lines c, BD, drawn parallel to the given rhumbs A *n*, A *o*.

Here are two right angled triangles BAC, BAD, to work in; there eing known in each, the ſide AB, and all the angles; whence the ſo- ition will be as in art. 347.

Answer. AD = 3,58 m. AC = 5,385 m. BD = 4,87 m. BC = 6,316 m.

Question XIV. *Coaſting along ſhore I obſerved two iſlands, the one re E. and the other W.; then ſailing SSE. $\frac{1}{2}$ E. $16\frac{1}{2}$ miles, the weſtern land bore NW. b. W. $\frac{1}{2}$ W. and the eaſtern bore NE. $\frac{1}{4}$ E.: Required their ſtance at each time of ſetting them?*

Here are two oblique angled triangles to work in; and the ſolution ill be as in art. 349; there being one ſide AB and all the angles known.

Answer. AC = 22,99 m. AD = 23,85 m. BC = 34,03 m. BD 21,67 m.

Question XV. *Three ſhips,* B, C, D, *ſail from the ſame road* A, *nd bound to different ports lying in the ſame parallel of latitude;* B's *courſe NW. b. N. diſtance* 12 *miles;* C's *courſe is NE. b. E.; and* D's *courſe is NE. $\frac{1}{2}$ E.: Required the diſtance of* C *and* D *from their ports, and alſo the iſtance of thoſe ports from one another?*

Having deſcribed the horizon, and drawn the meridian and parallel, t their interſection C repreſent C's port; draw the given rhumbs C *o*, C *n*, *r*; make C *o* = 12 miles, produce *n* C towards A, and parallel to *n* A raw *o* B, meeting the weſt line in B; draw BA parallel to *o* C, and draw D parallel to C *r*, meeting the eaſt line in D: Then A is the port ſailed om, and B, C, D are the ports bound to.

The ſolution of theſe triangles falls under art. 347 and 349; there be- g given one ſide and all the angles.

Thus ∠BAC = 8 points, ∠B = 5 points, ∠BCA = 3 points.

The ∠BAD = $9\frac{1}{2}$ points, ∠D = $1\frac{1}{2}$ points.

Answer. AC = 17,96 m. AD = 34,36 m. BC = 21,6 m. BD = 39,56 m.

QUESTION XVI. *Two ſhips,* A *and* B, *ſail from the port* C ; *ſails SSE.* 50 *miles, and* B *SW. b. S.* 40 *miles: Required their bear and diſtance; and how far* A *is to the ſouthward and eaſtward of* B?

Deſcribe the horizon, draw the meridian and parallel, and their terſection C repreſents the port ſailed from.

Draw the given rhumbs, in which take CA = 50, CB = 40; then and B repreſent the places the ſhips are come to.

Draw AB; thro' B draw the meridian BD, meeting the parallel drawn thro' AD: Then BD is the difference of latitude, DA the dep ture, and BA ſhews the bearing and diſtance ſought.

In the triangle CBA, find the unknown angles, and ſide BA by a 355.

Draw C*n* parallel to BA; then ∠SCA + ∠CAs (= ∠AC*n* (185) gi ∠SC*n* the bearing from B to C: And ∠SC*n* taken from 90° lea ∠BAD: Hence BD, DA, are found by art. 347.

ANSWER. BA = 43,33 miles, BD = 12,93 miles, DA = 41,36 mile
And the bearing from B to A is S. 72° 38′ E.

QUESTION XVII. *At ſunriſe, being four o'clock, a ſhip ſaw a ſl to the WNW. and a brig to the E. b. N.; they all came to anchor along one another at nine o'clock, each having run ſince ſunriſe five knots an ho and the ſhip's courſe was due north: Required the courſes ſailed by the ſl and brig, and their diſtance from the ſhip in the morning when ſhe them?*

Draw the *WNW.* and *E. b. N.* rhumbs *a o*, *a n*; aſſume any point in the meridian line for their anchoring place, and in the ſame line ta DA = 25 miles = the diſtance each ſailed; thro' A draw AC, AB, p rallel to *a o*, *a n*, and on D with the radius DA deſcribe a circle cutti AC, AB, in C, B: Then A is the ſhip's place, C the ſloop's, and B t brig's, at four in the morning.

Now ∠C = ∠DAC = ∠D*ao* = 6 points; therefore ∠ADC = 4 poin
And ∠B = ∠DAB = ∠D*an* = 7 points; therefore ∠ADC = 2 poin
The ſides AC, AB, will be found by art. 351.

Anſwer { CA = 19,13 miles, and C's courſe is NE.
BA = 9,755 miles, and B's courſe is NNW.

QUESTION XVIII. *Having dropt anchor in very deep water in a riv with a buoy and rope of* 50 *fathoms fixed to it, I fell down the ſtream t I had veered out* 140 *fathoms of cable, and then the buoy was* 120 *fatho a-head of me: Required the depth of water?*

Conſtruct the triangle ABC with the three given ſides, letting CA 120 be horizontal to repreſent the ſurface of the water.

Dra

Draw BD perpendicular to CA continued; then B repreſents the an-
or, A the buoy, C the ſhip, and BD the depth of water.

In the triangle ABC find by art. 345 the angle CAB; then its ſupple-
nt DAB will alſo be known; and in the right angled triangle ADB,
ſide AB and all the angles being known, the ſide BD may be found
in art. 347.

ANSWER. The depth of water DB is 48,71 fathoms.

QUESTION XIX. *Coming within ſight of two headlands bearing N.*
S. of each other, the ſouthern one bore from the ſhip due E. and the
r NE. b. E.; and after ſailing due E. 5 miles, the northern headland
NE. b. N. $\frac{1}{2}$ E.: Required the diſtance of thoſe headlands from one
ther, and their diſtance from the ſhip at each time of ſetting them?

n the eaſt and weſt line take BA = 5 miles; draw the *NE. b. E.*
NE. b. N. $\frac{1}{2}$ E. rhumbs B*n*, BD; thro' A draw AD parallel to B*n*,
ting BD in D; draw DC perpendicular to AB continued.

hen D and C are the headlands; A, B, are the ſhip's places at the
es of ſetting them, and AB the diſtance ſailed.

ow ∠A = (∠CB*n* by 185 =) 3 points; the ∠DBC = $4\frac{1}{2}$ points.

hen ∠ABD = $11\frac{1}{2}$ pts. (181); ∠ADB = $1\frac{1}{2}$ pts. and ∠BDC = $3\frac{1}{2}$ pts.

the triangle ABD having the ſide AB, and all the angles given, find
ſides AD, BD, by art. 349.

nd in the right angled triangle BCD, knowing the ſide BD and all the
es, find the ſides BC, CD, by art. 347.

NSWER. AD = 13,31 m. BD = 9,565 m. BC = 6,07 m. CD = 7,395 m.

UESTION XX. *Having caſt anchor I obſerved the bearings of a tower,*
ll and a lighthouſe, known to lie due eaſt and weſt of one another; the
r bore WSW. the mill SW. b. S. $\frac{1}{2}$ W. and the lighthouſe S. b. W.
.; the diſtance of the tower from the mill is $5\frac{1}{2}$ miles: How far are
of thoſe objects diſtant from the place where I anchored?

raw the given rhumbs B*r*, B*o*, B*n*; make BA = $5\frac{1}{2}$ miles; continue
B ill it meets AD, drawn parallel to B*r*, in D; draw DC parallel to B*n*:
T n D repreſents the ſhip's place, A the tower, B the mill, and C the
ghouſe.

he angles are made out, and the triangles are ſolved as in the laſt
qu tion.

NSWER. DA = 9,021 m. DB = 4,466 m. DC = 3,608 miles.

SECTION VII.

Of ſailing to windward.

701. When the wind is directly, or partly, againſt a ſhip's di courſe to the place ſhe is bound to, ſhe reaches her port by a kind zigzag or z like courſe; which is made by ſailing with the wind firſt one ſide the ſhip, and then on the other ſide.

In a ſhip, and looking towards the *ſtem* or *head.*

STARBOARD ſignifies the right hand ſide.

LARBOARD the left hand ſide.

FORWARDS or AFORE, is towards the head or ſtem of the ſhip.

AFT or ABAFT, is towards the hinder part or *ſtern.*

The BEAM ſignifies *athwart* or acroſs the middle of the ſhip.

702. When a ſhip ſails the ſame way the wind blows, ſhe is ſaid ſail or run before the wind; and the wind is ſaid to be *right aft*, or r *aſtern*; and her courſe is then 16 points from the wind.

When a ſhip ſails with the wind blowing directly acroſs her, ſh ſaid to have the *wind on the beam*; and her courſe is 8 points from wind.

When the wind blows obliquely acroſs the ſhip, the wind is ſaid be *abaft the beam*, or *afore the beam*, according as her courſe is mor leſs than 8 points from the wind.

When a ſhip endeavours to ſail towards that point of the com from whence the wind blows, ſhe is ſaid to *ſail on a wind*, or to p *windward.*

A veſſel ſailing as near as ſhe can to the point from whence the w blows, is ſaid to be cloſe hauled: The generality of ſhips will lie w in about ſix points of the wind; but ſloops and ſome other veſſels lie much nearer.

703. The *windward*, or *weather*, *ſide*, is that ſide of the ſhip which the wind blows; and the other ſide is called the *leeward*, o *ſide.*

Tacks and *ſheats* are large ropes made faſt to the lower corners of fore and main ſails, by which either of theſe corners are hauled for aft.

When a ſhip ſails on a wind, the windward tacks are always ha forwards, and the leeward ſheats aft.

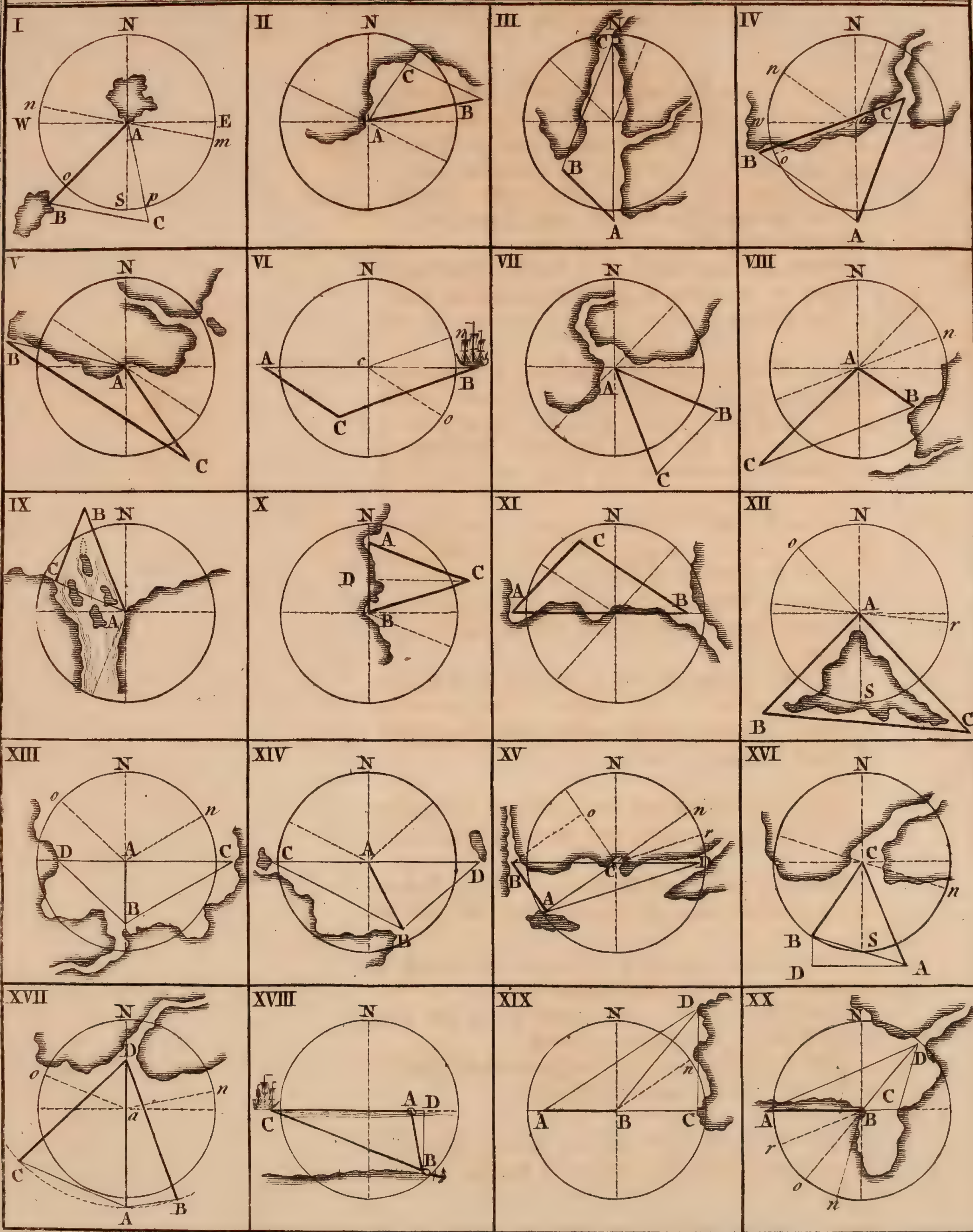
The *ſtarboard tacks are aboard* when the ſtarboard ſide is to wi ward, and the larboard to leeward.

And the *larboard tacks are aboard* when the larboard ſide is to w ward, and the ſtarboard to leeward.

704. To know how near the wind a ſhip will lie; obſerve the co ſhe goes on each tack, when ſhe is cloſe hauled; then half the num

OBLIQUE SAILING

Pl. III.



T. Jefferys sculp.

Page 274.

f points between the two courſes, will ſhew how near the wind that iip will lie.

705. The moſt common caſes in turning to windward may be conruĉted by the following precepts.

Having drawn the meridian and parallel of latitude (or eaſt and weſt ne) in a circle repreſenting the horizon of the place; mark in the cirimference the place of the wind; draw the rhumb paſſing thro' the ace bound to; and lay thereon the diſtance of that place from the ntre.

On each ſide of the wind, lay off in the circumference, the points or grees ſhewing how near the wind the ſhip can lie; and draw theſe umbs.

Now the firſt courſe will be on one of theſe rhumbs, according to the ck the ſhip leads with: Draw a line thro' the place bound to, parallel to the other rhumb and meeting the firſt, and this will ſhew the urſe and diſtance on the other tack.

The figures referred to in this ſection are in Plate IV. at the end; ierein they are marked by the number of the queſtion.

QUESTION I. *The wind at north, and I am bound to a port 25 miles ectly to windward, being on my ſtarboard tacks, and can lie within 6 nts of the wind: What muſt be my courſe and diſtance on each of two ks to reach my port?*

The conſtruction being done as above direĉted, N is the place of the nd, A the port bound to, and B the place where the ſhip is ſuppoſed be, when the port is 25 miles to windward of her.

Now as the ſhip leads with her ſtarboard tacks; that is, has the wind wing on her ſtarboard ſide, ſhe muſt firſt ſail along the line BC drawn allel to the rhumb A *n*, which is 6 points from the wind; and where other rhumb A *o*, alſo 6 points from the wind, being produced from owards C, meets with BC in the point C, is the place where ſhe muſt k about to reach her port within 6 points of the wind on her larboard ks.

Here BC being parallel to A *n*, the ∠B =(∠NA *n*, by 183, =) 6 points. And the ∠BAC = (∠NA *o*, by 183, =) 6 points; hence ∠C = 4 pts. Therefore, as ∠B = ∠BAC; the ſide BC = ſide CA (194)

Now as one ſide AB, and all the angles are given, the ſolution falls der art. 340 of oppoſite ſides and angles.

Therefore, As ſin. ∠C : AB : : ſin. ∠BAC : BC.

Or, As ſin. 45° 00′ : 25 m. : : ſin. 67° 30′ : 32,66.

ANWSER, the ſhip ſails { on her ſtarb. tacks *WNW*. 32,66 miles.
on her larb. tacks *ENE*. 32,66 miles.

QUESTION II. *A ſhip that is bound to a port* 80 *miles directly to w ward, then at NE. b. N.* $\frac{1}{2}$ *E. propoſes to reach her port at two boards within* 6 *points of the wind: Required her courſe and diſtance on each* *ſo as to double a rocky ſhelf lying in the NW. quarter?*

As the wind is in the *NE.* quarter, and the ſhip is to double a ſhe the *NW.* quarter, therefore ſhe muſt lead with her ſtarboard tacks; running from B, her preſent place, to C in a parallel to the rhumb 6 points from *w* the place of the wind; ſhe then tacks for her port A the direction of the rhumb A *o*, 6 points from *w*.

The manner of ſolution, is the ſame as in the laſt queſtion.

ANSWER, ſhe runs on her { ſtarb. tacks NNW. $\frac{1}{2}$ W. 104,5 miles.
larb. tacks ESE. $\frac{1}{2}$ E. 104,5 miles.

QUESTION III. *A ſhip bound to a port bearing NNE.* $\frac{1}{2}$ *E. muſt d a cape to the eaſtward: Now ſhe having run on her larboard tack* 15 *lea within* 6 *points of the wind then at N. b. E. the port bore NW. b. W.: Required how near the wind ſhe muſt lie on her ſtarboard tack, an diſtance of the port at each time of ſetting it?*

Here A is the place of the ſhip at firſt, B the port bound to; AC i run on the larb. tack, and CB that on the ſtarb. tack.

ANSWER { The diſtance AB from the port is 10,08 miles.
The run CB is 11,61 miles, and 6$\frac{1}{4}$ points from the w

---

QUESTION IV. *A ſhip being bound to a port bearing SSE. and di to windward, having run on her larboard tacks* 83$\frac{1}{4}$ *miles within* 6$\frac{3}{4}$ *p of the wind; on tacking about falls in with a rock at the ſame diſtance her port: What courſe muſt ſhe run on her ſtarboard tacks, how nea wind, and what was the port's diſtance at firſt?*

Here the ſide AC = CB; therefore ∠B = ∠BAC = 6$\frac{3}{4}$ points. Hence ∠C = 2$\frac{1}{2}$ pts. Alſo ∠B = ∠BA*n* = 6$\frac{1}{4}$ pts. Therefore ∠1 = 7$\frac{1}{4}$ points.

ANSWER { Starb. courſe E. b. N. $\frac{1}{4}$ E. 6$\frac{3}{4}$ points from the wind
The port's diſt. at firſt was 40,47 miles.

QUESTION V. *A privateer lying by with the wind at NNE. ſees a on her ſtarboard tacks that had juſt doubled a point* 18 *miles to the W. b. the ſloop run for her port within* 6 *points of the wind: The privateer chaſe at the rate of* 8 *knots an hour, and in* 4 *hours came up with her: quired the ſloop's rate of ſailing, and alſo the courſes of both veſſels?*

Draw BA to the *E. b. S.* and equal to 18 miles; on A with 32 n 8 × 4, cut the rhumb BC drawn 6 points from the wind, at *w*: T e privateer is firſt at A, ſees the ſloop at B, gives chaſe along the line , and takes the ſloop at C; and B*o* drawn parallel to AC ſhews the vateer's courſe from the north.

Here are known two ſides, AB, AC, and the ∠ABC = 13 points.

ANSWER { The ſloop ſails NW. at the rate of 3,86 m. per hour $= \frac{BC}{4}$.
The privateer's courſe N. 63,12 W.

QUESTION VI. *Being within ſight of my port bearing N. b. E.* ½ *E.* *ant* 18 *miles, a freſh gale ſprung up at NE.; then running* 48 *miles on larboard tacks within* 6 *points of the wind, I tacked about: Required courſe and diſtance to my port?*

From any point A draw AB, AC, parallel to *ao*, *an*, the *N. b. E.* ½ *E.* l *ESE.* rhumbs, the latter being 6 points from the wind at *NE.* Make AB = 18, AC = 48, and join BC. Then the ſhip at A firſt s her port at B, and ſailing from A to C on the larboard muſt go m C to B on the ſtarboard tacks.

Here are known two ſides, and the included angle A = 8½ points. erefore the ſolution will be as in art. 335.

ANSWER. The ſhip has to ſail 52,89 miles on a courſe N. 47° 42′ W.

QUESTION VII. *A ſhip bound to a port met a ſloop that had ſailed n thence SSW.* ½ *W.* 325 *miles, the wind being at N. b. E.; afterwards, ſhip having plied on her larboard tack for three days, ſhe met a veſſel who ſailed on a direct courſe SE. b. E.* ½ *E.* 412 *miles ſince ſhe departed n that port: Required the ſhip's courſe and diſtance between her meeting e veſſels, and how near the wind ſhe lay?*

Here B is the port bound to, A and C are the points where the ſhip t the veſſels, and AC the diſtance run; parallel to which, a line B*n* ng drawn will ſhew the courſe and diſtance from the wind.

ANSWER. The diſtance AC = 524,8 m. The courſe is N. 79° 51′ E.
6¼ points from the wind.

QUESTION VIII. *Being on my larboard tacks I met a ſnow that had d NE. b. N.* 284 *miles from the port I am bound to; and next day I a brig who had ſailed from thence* 326 *miles, with the wind, then at S. . two points abaft the beam: Required my courſe and diſtance between meeting thoſe veſſels; and how near the wind?*

Here B is the port, A and C the places of meeting.
There are known two ſides and the contained angle.

ANSWER { The ſhip had ſailed S. 64° 06′ E. 4¾ pts. from the wind.
The diſtance run was 125,9 miles.

QUESTION IX. *The wind at SW. and a ſhip plying to windward, a running* 450 *miles on her larboard tacks, and* 450 *on her ſtarboard ta finds ſhe has got* 300 *miles directly to windward: What were her cou and how near the wind?*

From any point A draw AB = 300 miles, and parallel to the w rhumb *a w*; on A, B, with 450 miles deſcribe arcs cutting in C; then lines AC, CB, being drawn, will ſhew the diſtances run on each tack

The point C is taken towards the *NW.* quarter as the ſhip leads v her larboard tacks; but had ſhe led with her ſtarboard, the point C n have been taken towards the *SE.* quarter.

The rhumbs *a o*, *a n*, being drawn parallel to AC, CB, will ſhew courſes on each tack.

Here are the three ſides given to find the angles: But two of the ſ being equal, the ſolution is readily performed as in art. 358.

ANSWER { Courſe on larb. is N. 64° 28′ W. / Courſe on ſtarb. is S. 25 32 E. } 6¼ pts. from the wi

---

QUESTION X. *A pyrate being in chaſe of a ſloop* 15 *miles ahead to WSW. both on the ſtarboard tacks, the wind at NW.; the ſloop finding loſt way tacked about for an iſland in the NW. quarter,* 11 *miles diſ from her, and* 13 *from the pyrate: Required how near the wind muſt ſloop run, and whether the pyrate can continue the chaſe?*

ANSWER { The ſloop's courſe is N. 10° 05′ E. 5 pts. from the w
The pyrate's courſe is N. 66° 54′ W. 2 pts. from the w
Therefore he cannot continue the chaſe.

QUESTION XI. *Being on a NE. courſe with my larboard tacks, an iſ bore SW. diſtant* 12 *miles, and my port bore NNW.; the diſtance of iſland and port is* 40 *miles: Now the wind being at NNW. ½ W. and I lie no nearer than* 6½ *points: Required how far I muſt run on my pre courſe before I tack about, and alſo the courſe and diſtance I have then to ſte*

In a *SW.* rhumb, from any point A take AC = 12 miles; and C with a diſtance of 40 miles cut AB drawn parallel to the *NNW.* rhu *a n*; now the rhumb *a o* being taken 6½ points from the wind, thr draw BD parallel to *a o*, meeting CA continued in D.

Then A is the ſhip's place, C the iſland, B the port bound to; A the diſtance to run on the larboard tacks, and BD on the ſtarboard

In the triangle CBA there are known CA, CB, and ∠CAB = ∠C *a n* 10 pts.; then finding AB (352), in the triangle ABD one ſide and all angles being known, the ſides AD, DB, are found as in art. 349.

The ∠D = C *a o* = 3 pts. ∠BAD = ∠D *a n* = 6 pts. ∠ABD = 7

ANSWER { The diſtance run on the NE. courſe is 59,75 miles.
On the ſtarb. ſhe muſt run W. b. S. diſt. 56,28 miles.

QUEST

Question XII. *A ſhip ſailing cloſe by a point ſees two lighthouſes, one miles to the NE. b. E. the other* 8 *miles to the SE. b. S.; the ſhip is on larboard tacks within* $6\frac{1}{4}$ *points of the wind, then at SE. b. E.: Re-red how far ſhe muſt run to bring the lighthouſes to bear in one line; and at will be the bearing and diſtances of them from the ſhip at that time?*

From any point C draw CA parallel to *a n* the *NE. b. E.* rhumb, and ual to 18 miles, alſo draw CB parallel to *a o* the *SE. b. S.* rhumb, and ual to 8 miles; join AB, which produce till it meets in D the line drawn parallel to *a r*, a rhumb $6\frac{1}{4}$ points from the wind at *SE.* Then C is the ſhip's place at firſt; A, B, are the lighthouſes; CD the ance run to ſee them in one right line DBA; then a rhumb *a s* drawn pallel to DA ſhews their bearing at that time.

n the triangle ACB, knowing two ſides and the included ∠C = ∠*nao* = 3 points; the other angles, and ſide AB is found as in art. 353.

n the triangle ACD, knowing CA, the ∠ACD = ∠*nar* = $13\frac{1}{4}$ pts. the ∠A found before, the diſtance CD, AD, are found as in art. 349.

NSWER
The ſhip runs on her larb. S. b. W. $\frac{1}{4}$ W. diſt. 23,38 m.
Then the lighhouſes bear N. 32° 17′ E.
The diſtance of A being 38,66 miles, and of B 18,96 miles.

Question XIII. *A ſhip wants to reach on two tacks, a port bearing . b. S. but muſt double a point bearing S. b. E. the point being* 25 *miles e NE. b. E. of the port; the ſhip can lie no nearer the wind now at . than* $6\frac{1}{2}$ *points: Required her courſe and diſtance on each tack?*

ake C the point, 25 miles to the *NE. b. E.* of B the port; thro' C v CA parallel to B *n* the *S. b. E.* rhumb, and its meeting with *o* B the . *b. S.* rhumb produced northward, gives A the ſhip's place; then AD DB being drawn in the directions of the rhumbs B *s*, B *r*, $6\frac{1}{2}$ points n the wind at *w*, ſhew the runs on each tack.

n the triangle ABC, there is known BC, ∠BAC = ∠*o*B*n* = 4 points, BC = 2 points, ∠C = 10 points; then AB is found as in art. 349.

n the triangle ABD, AB is now known, ∠BAD = ∠*o*B*s* = $5\frac{1}{2}$ pts. BD = ∠*o*B*r* = $7\frac{1}{2}$ points, ∠D = 3 points; hence AD, DB, are d as in art. 349.

NSWER
Courſe on ſtarb. is SSE. $\frac{1}{2}$ E. diſt. 58,51 miles.
Courſe on larb. is NW. b. W. $\frac{1}{2}$ W. diſt. 51,85 miles.

Question XIV. *A privateer lying behind a low point* 6 *miles to the b. W. ſees a ſhip to the SSE. coming out of a port* 18 *miles diſtant the point; the ſhip ſteered NW. with a briſk gale at SSW.; the priva-ſlipt his cable and gave chaſe within* $6\frac{1}{2}$ *points of the wind and takes How far had each run when they met?*

ake A, 6 miles to the *NE. b. E.* of C the point; from C with 18 miles AB drawn parallel to C *o* the *SSE.* rhumb, and B is the port the ſhip ſailed from; then AD drawn $6\frac{1}{2}$ points from the wind meeting drawn *NW.* the interſection D is the place where the privateer m the ſhip.

In the triangle ACB, is given AC, CB, and ∠CAB = ∠*n*C*o* = 7 find AB.

Then in △ ABD, where ∠DAB = ∠*r*C*o* = $10\frac{1}{2}$ pts. ∠DBA = 2 ∠ADB = $3\frac{1}{2}$ points, find the ſides AD, BD, as in art. 349.

ANSWER { The ſhip had ſailed NW. diſt. 25,27 miles.
The privateer ſailed W. b. N. $\frac{1}{2}$ W. diſt. 10,96 mile

---

QUESTION XV. *A ſhip that can lie within* 6 *points of the wind a headland* 21 *miles to the NE. which ſhe is to weather in order to an iſland* 9 *miles to windward thereof, the wind being at eaſt: What c and how far muſt ſhe go on each tack, ſhe leading with the ſtarboard?*

Draw BA = 21 m. to the *SW.* BC = 9 m. to the *eaſt*, join AC; c AD, CD, each 6 points from the wind; then A is the ſhip's place, B headland, C the iſland; AD the run on the ſtarboard tacks, and DC of the larboard.

In the △ ABC, is given BA, BC, ∠ABC = 12 points; find the c ∠s, and AC.

Then in the △ ACD, is known AC, and all the angles, to find AD, Thus ∠D = 4 pts.; ∠DCA = ∠DCB + ∠BCA; ∠CAD = ∠BAD + ∠I

ANSWER { On the ſtarb. ſhe runs 39,19 miles on the NNE. rhu
On the larb. ſhe runs 23,12 miles on the SSE. rhum

QUESTION XVI. *There is a certain port, which to ſail into you bring the port and a mill* 4 *miles to the eaſt thereof, to bear due weſt the ſame time a beacon* 5 *miles to the NE. b. N.* $\frac{1}{2}$ *E. of the mill, bear b. E.* $\frac{3}{4}$ *E.; and then ſteer directly for the beacon and thence to the Required the beſt wind in the NW. quarter for a ſhip that goes equally on both tacks, together with the diſtance ſhe muſt run on each tack from ſaid ſituation to the port?*

In the *W.* rhumb take BC = 4 miles, and in the *NE. b. N.* $\frac{1}{2}$ *E.* rh take BD = 5 miles; join DC, and parallel to the *N. b. E.* $\frac{3}{4}$ *E.* rh B*n*, draw DA meeting CB continued in A.

Then C is the port, B the mill, D the beacon, and A the ſhip's p

In the △ BAD, is given BD and all the angles, to find AD.

In the △ CBD, is given BC, BD, and ∠CBD, to find the other ar and DC.

Draw the rhumb B*o* parallel to DC; then the ∠*n*B*o* being biſe will give the place of the wind as required.

ANSWER { She will run on her larb. N. b. E. $\frac{3}{4}$ E. diſt. 4,105 m
And on her ſtarboard S. 61° 40′ W. diſt. 8,145 miles.
The beſt wind is that blowing from the NW. $\frac{1}{2}$ W. ne

QUEST

QUESTION XVII. *A ſloop in doubling a point directly to the eaſt of port, ſees a lighthouſe bearing NNW. ½ W. which ſhe knows lies NE. N. ½ E. from the port, and is 10 miles to the NE. b. E. ¾ E. of a on bearing due north of her port: The wind is at W. b. N. ½ W. and can lie within 5 points: Required her diſtance on each tack, ſhe leading h the larboard, and keeping cloſe to the lighthouſe when ſhe tacks?*

uppoſe D the beacon, make DC = 10 miles in the *NE. b. E.* ¾ *E.* mb, and C is the lighthouſe; draw CB parallel to the *NE. b. N.* ½ *E.* nb D *n*, and its interſection B with the *S.* rhumb DB is the port; thro' nd C, lines being drawn parallel to the *E.* and *NNW.* ½ *W.* rhumbs, r interſection A is the place of the ſhip.

n the △ CDB is given DC and all the angles; hence BC is found. (349)

n the △ CBA there is known CB and all the angles; hence AC is d as in art. 349.

ere ∠DBC = 3½ points, ∠BDC = 10¼ points, ∠DCB = 2¼ points.

nd ∠ABC = 4½ points, ∠BAC = 5½ points, ∠ACB = 6 points.

NSWER { The diſtance on the larboard tacks is 12,49 miles.
The diſtance on the ſtarboard tacks is 14,25 miles.

UESTION XVIII. *A ſhip that can lie on either tack within 6 points of wind then at ESE., having her ſtarboard tacks aboard, ſees her port tly to windward, and a headland that lies 6 miles to the NW. of her bore E. b. N.: Now ſhe wanting to reach her port at two boards; re-d her courſe and diſtance on each, and alſo the bearing and diſtance of eadland when ſhe tacks?*

et C be the headland, and B, 6 miles to the *SE.* be the port; thro' d B draw lines parallel to the *E. b. N.* and *ESE.* rhumbs, their ſection A is the ſhip's place; lines drawn thro' A and B parallel to humbs, 6 points from the wind, will meet in C, the place where hip muſt tack; draw DC, and this ſhews the poſition and diſtance of headland from the ſhip when ſhe tacks.

the △ ACB is given BC and all the angles; find AB = 8,979.

the △ ABD is known AB and all the angles; find AD, BD.

the △ BCD is known BC, BD, and ∠CBD; find the other angles CD.

ere ∠ACB = 11 points, ∠CAB = 3 points, ∠ABC = 2 points.

he ∠BAD = 6 points, ∠ABD = 6 points, ∠ADB = 4 points, and D = 4 points.

NSWER { Ship runs on ſtarboard 11,73 miles NE.
on larboard 11,73 miles S.
Headland bears when ſhe tacks S. 29° 32′ W. diſt. 8,607 m.

QUESTION XIX. *A ſhip on her ſtarboard tacks paſſing by a point her port 8 miles to the E. b. N. and at the ſame time a cliff, which l the NW. b. W. of the port, bore N. b. E.; the ſhip on her ſtarboard lie within $6\frac{1}{2}$ points of the wind, then at NE. b. E. $\frac{1}{2}$ E., and with points on the larboard; ſhe propoſes to reach the port on two boards: Requ her courſe and diſtance on each, together with the bearing and diſtance o cliff when ſhe tacks about?*

Here the point C is taken for the cliff, in order to bring the fi within the limits; but if A, repreſenting the ſhip's place, was take the centre, the conſtruction would be more ſimple.

In the *E. b. N.* rhumb, take C *a* = 8 miles; draw *a* B parallel to *S. b. W.* meeting CB drawn *SE. b. E.* in B, which is the port bound draw BA parallel to *a* C, meeting the *S. b. W.* rhumb in A, which is ſhip's place; thro' A draw AD parallel to a rhumb $6\frac{1}{2}$ points from wind, and thro' B draw BD parallel to a rhumb 7 points from the w their meeting D is the place where the ſhip is to tack; then DC b drawn ſhews the bearing and diſtance of the cliff from the ſhip wher tacks.

In the △ CAB, is given BC = AB and all the angles; find CA = 6,

In the △ ABD, is given AB and all the angles; find AD, BD.

In the △ ACD, is known AC, AD, and ∠CAD; find the other an and CD.

ANSWER
Courſe on ſtarb. is N. b. W. diſtance 14,96 miles.
Courſe on larb. is SE. b. S. $\frac{1}{2}$ E. diſtance 16,97 miles.
The cliff on tacking bore S. 25° 22′ E. diſt. 9,596 m

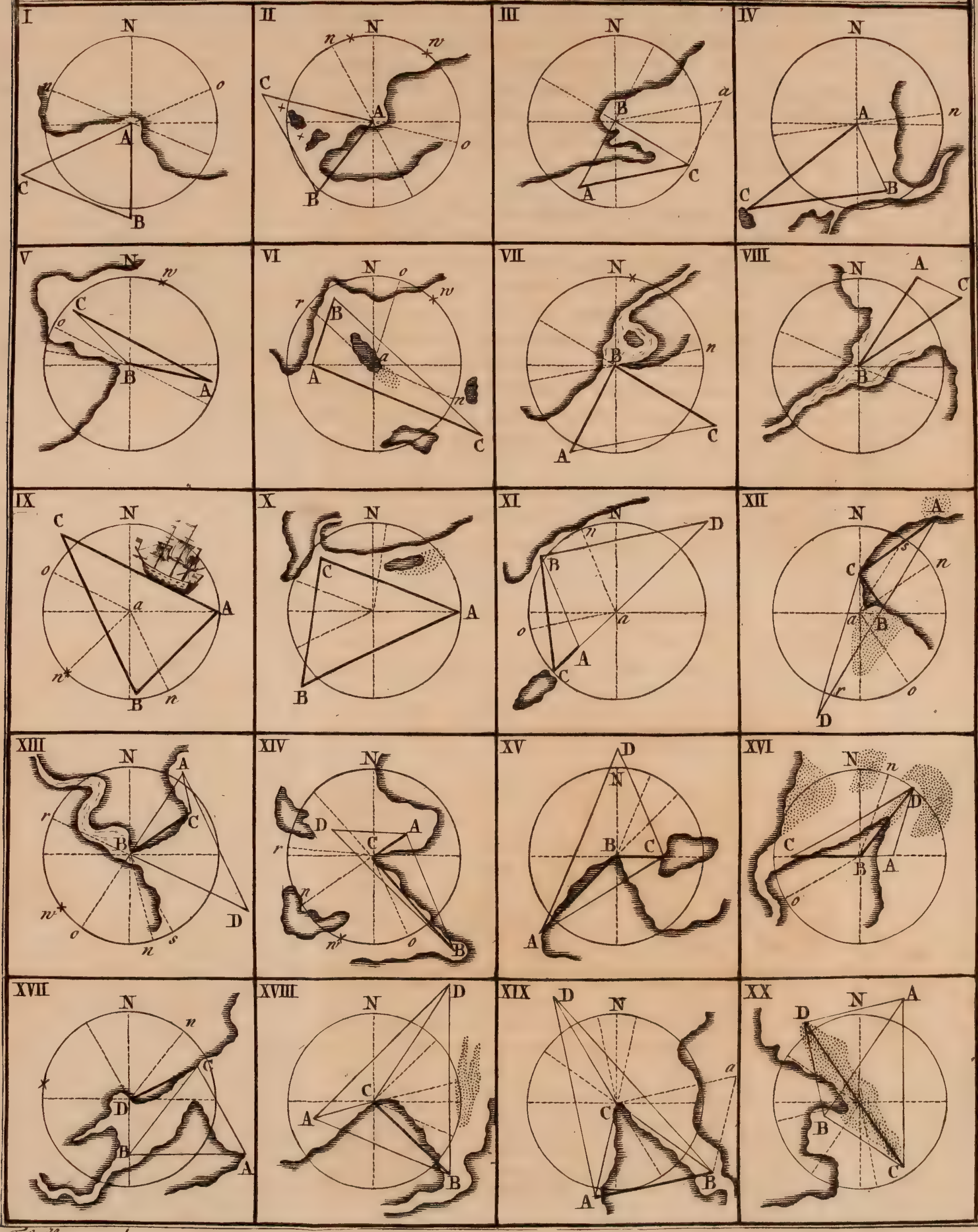
QUESTION XX. *A ſloop at ſea diſcovers two beacons at the extre of a ſhoal, the one bearing W. b. S. and the other which bore S. was 9 to the SE. b. S. of the northern beacon; the port bound to lay NW. b. of one beacon, and S. b. E. of the other: Now the veſſel can lie within points of the wind then in the SW. quarter, and it being high water ſhe tack cloſe to the ſouthern beacon: Required the place of the wind, with courſe and diſtance on each of two boards to gain her port; and alſ bearing and diſtance from the port when ſhe firſt ſaw the beacons?*

The conſtruction and ſolution of this queſtion being not much un the two laſt, they are here omitted to exerciſe the learner's ſkill.

ANSWER
The Wind is SW. b. W. $\frac{1}{2}$ W.
Courſe on ſtarb. is S. diſtance 8,478 miles.
Courſe on larb. is NW. b. W. diſtance 4,87 miles.
Port bore S. 35° 03′ W. diſtance 7,05 miles.

SECTI

SAILING ON A WIND. Pl. IV.



T. Jefferys sculp.

Page 282.

SECTION VIII.

Of ſailing in currents.

706. A CURRENT or TIDE is a progreſſive motion of the water, uſing all floating bodies to move that way, towards which the ſtream directed.

The *ſetting of a tide*, or *current*, is that point of the compaſs towards ich the waters run; and the *drift of a current* is the rate it runs per ur.

The ſetting and drift of the moſt remarkable tides and currents are tty well known: But in unknown currents, the uſual way to find the ting and drift, is thus.

Let three or four men take a boat a little way from the ſhip; and by rope, faſtened to the boat's ſtem, let down a heavy iron pot, or ded kettle, into the ſea to the depth of 80 or 100 fathoms, when it n be; whereby the boat will ride almoſt as ſteady as at anchor: hen heave the log, and the number of knots run out in half a minute ll give the miles which the current runs per hour; and the bearing the log ſhews the ſetting of the current.

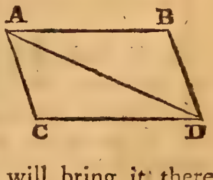
707. A body moving in a current may be conſidered in three caſes. mely, Moving with, or the ſame way the current ſets.
Moving againſt, or the contrary way the current ſets.
Moving obliquely to the current's motion.

When a ſhip ſails with the current, its velocity will be equal to the n of its proper motion, and the current's drift.

When a ſhip ſails againſt a current, its velocity will be equal to the erence of the current's drift and its own motion.

So that if the current drives ſtronger than the wind, the ſhip will drive ern, or loſe way.

When the courſe ſet is oblique to the drift of the current, the ſhip's l courſe, or that made good, will be ſomewhere between that in ich the ſhip endeavours to go, and the track in which the current es to drive it: That is, it will always be along the diagonal of a paelogram, wherein one ſide repreſents the ſhip's courſe ſet, and the er adjoining ſide is the current's drift.



For ſuppoſe ABCD be a parallelogram, whoſe diagonal is AD.

Now if the wind alone would drive the ſhip from to B, in the ſame time as the current alone would ve it from A to C.

Then as the wind neither helps nor hinders the p from coming towards the line CD, the current will bring it there the ſame time as if the wind did not act.

And as the current neither helps nor hinders the ſhip from coming ards the line BD, the wind will bring it there in the ſame time as if current did not act.

Therefore the ſhip muſt, at the end of that time, be found in both thoſe lines; that is, in their meeting D.

Conſequently the ſhip muſt have paſſed from A to D, in the diagona AD.

708. When the ſhip's courſe and diſtance by account, and the ſettin and drift of the current are given; the true courſe and diſtance of th ſhip may be found either by working a traverſe, in which the ſettin and drift of the current are uſed as a courſe and diſtance; or by a trigonometrical ſolution of the triangles forming the figure: Which is thu conſtructed.

From the centre of a circle draw the ſhip's proper courſe and diſtance and the current's ſetting and drift; with theſe two lines form a parallelogram; and from the centre draw a diagonal, which will ſhew th ſhip's real courſe and diſtance.

709. It may frequently happen, that a ſhip is plying to windward acroſs a tide's way. In ſuch caſes,

Firſt conſtruct the figure for the plying to windward.

Then with the courſe on each tack, and the ſetting of the current form parallelograms, one of whoſe ſides in each muſt be the ſhip's rate and the other the current's drift.

And lines drawn to meet one another, from the centre and port boun to, parallel to the diagonals of thoſe parallelograms, will ſhew th courſes and diſtances the ſhip muſt run on each tack.

The figures referred to in this ſection are at the end in Plate V wherein they are marked by the number of the queſtion.

QUESTION I. *A ſhip ſails E. 5 miles an hour, in a tide ſetting the ſame way 4 miles an hour: Required the ſhip's courſe, and the diſtance made good?*

The ſhip's motion is 5 m. E.
The current's motion is 4 m. E.

The ſhip's true run is 9 m. E.

In this caſe, as the ſhip ſails from A, the ſame way the tide ſets; therefore her motion will be quickned by as much as is the tide's motion.

QUESTION II. *A ſhip with briſk gale ſails SSW. at the rate 9 miles an hour, in a current ſettin NNE. 2 miles an hour: Requir the ſhip's courſe, and the diſtan made good?*

The ſhip's motion is SSW. 9 m.
The current's mot. is NNE. 2 m.

The ſhip's true run is SSW. 7 m.

Here as the ſhip ſails in a contrary direction to the tide, its motion will be ſlower by as much the tide acts againſt the motio given by the wind.

QUESTION III. *At 10 o'clock in the forenoon, a ſhip that was running ur miles an hour, comes in ſight of her port bearing ENE.; but finding, three o'clock in the afternoon, that ſhe had made no way, ſuſpects a cur-nt, which on trial was found to ſet WSW. five miles an hour: What has en the courſe and real run of the ſhip during this time?*

In this caſe, had there been no current, the ſhip in 5 hours would ve got a-head 20 miles from A to B: And had ſhe been becalmed, ſhe ould have drove with the current 25 miles from A to C: Conſequently e difference AD of theſe motions, is the way the ſhip has run; that is, e has drove a-ſtern 5 miles.

QUESTION IV. *A ſhip in doubling a cape meets a ſtrong tide ſetting E.; and after running SW. 18 miles by the log, the cape bore N. $\frac{3}{4}$ E.: equired the cape's diſtance, and the drift of the current?*

From A the cape, and centre of the horizon, draw AB in the *SW.* umb, and equal to 18 miles; thro' B draw BC parallel to the ſetting of e tide in the *SE.* rhumb A *n*; then AC drawn *S.* $\frac{3}{4}$ *W.* its interſection with BC, ſhews the ſhip's place; and that ſhe has run the line AC hile the tide runs the length of BC, or A *n*.

In the triangle ABC is given AB and all the angles, to find AC, BC. The ∠B = 8 points, ∠BAC = 3$\frac{1}{4}$ points, ∠ACB = 4$\frac{3}{4}$ points.

ANSWER { The ſhip has run 22,41 miles S. $\frac{3}{4}$ W.
The tide has run 13,35 miles SE.

QUESTION V. *A ſhip falling in with a current ſetting NNW. $\frac{1}{2}$ W. ſcovers a riff of rocks on the larboard, the eaſtern point whereof is 9 miles the NE. b. N. $\frac{1}{2}$ E.; which can be weathered by ſteering E. b. S.: Re-ired the diſtance the ſhip muſt run by the log, and alſo the drift of the rrent?*

Here A is the ſhip's place, C the eaſtern point of the rocks to be wea-ered, AB the courſe ſhe muſt ſhape in order to run along the line AC, hich is the diagonal of the parallelogram formed by the ſuppoſed way B of the ſhip, and A *n* the current's drift.

ANSWER { The apparent run by the log is 10,76 miles.
And the drift of the current is 10,27 miles.

QUESTION VI. *A ſhip in croſſing the mouth of a river, into which the de ſet due eaſt, ſails from a buoy on the ſouth ſide, NE. 10 miles, and then lls in with another buoy on the north ſide, diſtant from the firſt 15 miles: equired the ſhip's courſe, with the drift of the current?*

In the *SW.* rhumb take BA = 10 miles; on A with 15 miles cut t
E. rhumb BC in C: Then A repreſents the ſouthern buoy, C the n
thern one; AB is the ſhip ſuppoſed run, AC the real run, and BC t
drift of the tide.

Here is given AB = 10, AC = 15, the ∠B = 12 points.

ANSWER { The ſhip's courſe is N. 61° 52′ E.
The tide's drift is 6,161 miles.

QUESTION VII. *At 11 o'clock in the evening having weathered a c*
on my ſtarboard, a lighthouſe bore SW. b. S. and a ſtrong tide was ſett
WSW. ½ W. at the rate of 3½ miles an hour; at 4 in the morning we pa
over a ſandy point 28½ miles from the cape: Required the diſtance betw
the lighthouſe and cape, alſo the courſe the ſhip has run?

In the *ENE.* ½ *E.* rhumb take BA = 17½ miles (= 3½ × 5) for
tide's drift. On A with 28½ miles cut the *SW. b. S.* rhumb in C
ſandy point; thro' A and C, lines drawn parallel to BC, AB, their
terſection D is the lighthouſe.

ANSWER { The diſtance AD or BC is 12,72 miles.
The ſhip's courſe along AC is S. 56° 41′ Weſt.

QUESTION VIII. *A ſhip running ſouth at the rate of 5 miles an ho*
in 10 hours croſſes a current which all that time was ſetting weſt at the r
of 3 miles an hour: Required the ſhip's true courſe and diſtance ſailed?

Here the ſhip is firſt ſuppoſed to be at A, her imaginary courſe is al
the line AB; but her real courſe is along the line AC, the diagonal
the parallelogram, whoſe known ſides are, AB = 50 miles (= 10 ×
and BC = 30 (= 3 × 10).

ANSWER. The courſe is S. 30° 58′ E. diſtance 58,31 miles.

QUESTION IX. *Suppoſe a ſhip in 24 hours ſails NE. 100 miles by*
log, in a current ſetting E. b. S. 1¾ miles an hour: What is the courſe
diſtance made good?

Draw AB *NE.* and equal to 100 miles, thro' B draw BC parallel to
E. b. S. rhumb, and make it 42 miles (= 1¾ × 24); then draw
which ſhews the true run of the ſhip from A.

Here are given two ſides AB, BC, and ∠B = 11 points.

ANSWER. The courſe is N. 60° 49′ E. diſtance 128,2 miles.

Question X. *A ſhip departs from her port at 8 o'clock in the even- ;, and ſails before the wind then at NNW. at the rate of* 3½ *knots an ur, in a tide running at the ſame rate towards the eaſtward; and next day noon ſhe found herſelf* 84 *miles diſtant from her port: Required the p's true courſe and the ſetting of the tide?*

In the *NNW.* rhumb take BA = 56 miles (= 3½ x 16 h.), on A with miles, cut an arc deſcribed from B with 56 miles, their interſection C the place the ſhip is come to, A being the port ſailed from; AC the aginary courſe before the wind, BC the run of the current, and AC real run of the ſhip.

Here BA = BC, and the ſolution is as in art. 358.

Answer { The ſhip's true courſe is S. 63° 55′ E.
The ſetting of the current is N. 74° 40′ E.

Question XI. *A ſhip in the evening departs for an iſland* 46 *miles the WSW. but by a ſtrong tide running to the ſouthward, ſhe found ſelf next morning on a ſhoal* 65 *miles from her departed port, and* 34 *les from the iſland: Required the bearing of her port and the ſetting of tide?*

Here A is the port ſailed from, B the iſland bound to, C the ſhoal me to; the conſtruction as in the laſt, and the ſolution as in art. 357.

Answer { The port bears N. 37° 37′ E.
The current ſet S. 4° 56′ E.

Question XII. *A ſhip in latitude* 41° 18′ *N. is bound to a port in itude* 46° 30′ *N. lying* 258 *miles to the weſt; where being arrived, finds her dead reckoning that ſhe has made* 384 *miles of northing, and* 206 *miles weſting: Required the ſetting and drift of the current that occaſioned this ference?*

Here by the dead reckoning the ſhip ſhould have gone from A to B; t ſhe being arrived at the port C, the ſetting and drift of the current ll be repreſented by the line BC; which is the hypothenuſe of the angle BFC, whoſe legs are the differences between the real and imaary differences of latitude and departures.

For the current ſetting ſouthward, will cauſe the ſhip to be longer ting to the northward, and thereby increaſe her account of northing; d by its ſetting weſtward, quickens the ſhip's motion that way more an her account ſhews.

Answer. The current's courſe is S. 35° 50′ W. and drift 88,82 m.

QUESTION XIII. *A ſhip from a place in latitude 37° 40′ N. ſails SS diſtance 48 miles in 10 hours; then ESE. 72 miles in 14 hours; and all the time been in a current ſetting SSW. 1½ miles an hour: Required ſhip's preſent latitude and departure, together with the direct courſe and d tance ſhe has ſailed?*

As the current has run 1½ miles an hour for 24 hours, its whole dr is 36 miles.

The beſt way of ſolving this queſtion is to conſider the current as a other courſe and diſtance, and then with the three courſes and diſtan form a traverſe table, as ſhewn in art. 695.

TRAVERSE TABLE.

Courſes.	D.	N.	S.	E.	W.
SSW.	48		44,3		18,4
ESE.	72		27,6	66,5	
SSW.	36		33,3		13,8
			105,2	66,5	32,2
				32,2	
				34,3	

The ſouthing and eaſting t ſhip has made being thus know the direct courſe and diſtance w be found as in art. 692.

Here the ſhip departs from A, a is come to C; AB being the d lat. and BC the departure.

ANSWER { The preſent lat. is 35° 55′ N. depart. 34,3 miles.
Direct courſe is S. 18° 03′ E. diſtance 110,7 miles.

QUESTION XIV. *Yeſterday noon we were in latitude 28° 14′ N. have ſailed till this day noon theſe courſes, viz. SSE. ½ E. 24 miles; N b. E. ½ E. 15 miles; ESE. ¼ E. 45 miles; and all this time we were i current ſetting S. b. W. 1¾ miles an hour: Required the ſhip's preſent la tude, departure, direct courſe and diſtance?*

TRAVERSE TABLE.

Courſes.	D.	N.	S.	E.	W.
SSE. ½ E.	24		21,2	11,3	
NE.b.E ½E.	15	7,1		13,2	
ESE. ¼ E.	45		15,2	42,4	
S. b. W.	42		41,2		8,2
		7,1	77,6	66,9	8,2
			7,1	8,2	
		D.lat.	70,5	58,7	Dep

Here the current being conſid ed as a courſe, the traverſe ta gives the diff. lat. = 70,5 mi and the depart. = 58,7 mi And hence the direct courſe is 39° 47′ E. and the diſtance 91,73 miles.

In any queſtion, where there are given one or more courſes diſtances ſailed, and alſo the ſetting and drift of the current, the w may be performed as above.

The reaſon of this is pretty evident; for as each courſe and diſta is affected by the current; therefore inſtead of correcting them one one, as ſhewn in moſt of the preceding queſtions, they may be all lowed for together, by making a courſe and diſtance of the quality quantity of the current.

QUESTI

QUESTION XV. *At 8 o'clock in the evening, a ſhip ſailed from her t on a SSW. courſe, 4 miles an hour; a ſtrong tide was then ſetting be- een the S. and W.; and at 6 o'clock in the morning ſhe paſſed by a rock miles to the weſtward, and 60 miles to the ſouthward of her port: Re- red the ſetting and drift, per hour, of the tide?*

With 60 miles as a diff. lat. and 70 miles as a departure, find the ce of the rock at C; A being the place ſailed from; in the *SSW.* umb take AB = 40 (= 4 × 10); draw BC, AC: Then AB is ſuppoſed courſe, AC the real courſe, and BC the ſetting and drift of tide.

In the △ ADC, is given AD, DC, ∠D; to find the ∠s and AC = 92,2.

In the △ ABC, is known AC, AB, ∠CAB; to find ∠s and BC = 59,37.

ANSWER. The tide ſets S. 67,09 W. and runs 5,937 miles an hour.

QUESTION XVI. *At ſix o'clock in the forenoon a ſhip weathered a e in latitude 46° 32′ N.; and having run SE. b. S. 24 miles by the log in urrent, found herſelf at noon in latitude 46° 17′ N. and the cape bore NW.: Required the ſetting and drift of the current?*

Make AD = the diff. lat.; draw the departure DC, meeting the *ESE.* umb in C; draw AB, *SE. b. S.* and equal to 24 miles, and join BC.

Then A is the cape, C the place come to, AB the ſuppoſed run, BC drift of the current, and AC the real run.

In the △ ADC, is given AD and the angles; to find AC = 39,2.

In the △ ABC, is known AB, AC, ∠BAC; to find the angles and = 23,41 m.

Then drawing the rhumb A *n* parallel to BC, it ſhews the ſetting of current.

ANSWER. The current ſets N. 77° 47′ E. and runs 3,9 miles an hour.

QUESTION XVII. *A ſhip bound from Dover to Calais lying 21 miles he SE. b. E. ½ E.; and the tide of flood ſetting NE. ½ E. 2½ miles an r: Required the courſe ſhe muſt ſteer, and the diſtance run by the log at rate of 6 miles an hour, to reach her port?*

In the poſition of the *SE. b. E. ½ E.* rhumb draw DC = 21 miles; and allel to the *NE. ½ E.* rhumb draw DE = 2½ miles; on E with 6 miles DC in F; draw DB parallel to EF, meeting CB drawn parallel to DE.

Then D is Dover, C Calais; and the ſhip by trying to ſail along the e DB, will be driven between it and the current in the line DC.

ANWSER. The ſhip muſt ſail S. 39,14 E. and will run by the log 19,4 m.

QUESTION XVIII. *Yeſterday noon we were in latitude* 42° 20′ *N. a this day at noon find ourſelves in latitude* 41° 10′ *N.*; *by our account we ha ſailed SW. b. S.* 189 *miles, and all the time have been in a current ſetti NW.: Required the ſhip's direct courſe and diſtance, with the current's dr per hour?*

Take AD = 70 miles, the diff. lat. draw AB parallel to *a n*, the *Sl b. S.* rhumb, and equal to 189 miles; thro' B draw BC parallel to t *NW.* rhumb *a o*, meeting the departure DC, and join AC.

Then the ſhip from A ſuppoſes herſelf ſailing along AB; but by the a tion of the current is driven along AC.

In the △ ADB, is given AD, AB, ∠BAD; required the angles a DB = 136,4.

In the △ DBC, is known DB and the angles; to find DC = 192 a BC = 123,1.

In the △ ADC, is known AD, DC, ∠ADC; to find the angles a AC = 204,4.

ANSWER { The courſe is S. 69° 58′ W.; diſtance 204,4 miles.
The current's drift per hour is 5,13 miles.

QUESTION XIX. *There are two ports which lie* 270 *miles to the no and ſouth of one another; a ſhip ſails from the northern port with her ſt board tacks aboard within* 72 *degrees of the wind then at S. at the rate* 4 *miles an hour, in a current ſetting ſouth* 2 *miles an hour: Required courſe and diſtance on each tack to reach the ſouthern port?*

From a point A in a line AD drawn S. 72° E. draw AB = 270 m to the ſouth; thro' B draw BD parallel to F *n*, a rhumb 72° from wind; then was there no current, the ſhip muſt ſail from A to D the ſtarboard, and from D to B on the larboard tacks.

Take F *a* = 2 miles, draw *a c*, *a c*, parallel to FD, F *n*, and make *a c*, each of 4 miles; draw the diagonals F *c*, F *c* of thoſe parallelograr then thro' A and B, lines drawn parallel to F *c*, F *c*, meeting in C, ſhew the run of the ſhip on each tack.

Here the triangles F *a c*, F *a c*, being congruous by conſtructi therefore the ∠CAB (= ∠*a* F *c*) is equal to ∠CBA (= ∠*a* F *c*).

Now in the triangle *a* F *c*, is given *a* F, *a c*, ∠F *a c* = 108°; fi whence the other angles are known; *viz.* ∠*a* F *c* = 49° 37′.

Then in the triangle ABC, is known the ſide AB, and all the ang whence the ſides AC and CB are eaſily found.

ANSWER { The courſe on ſtarb. is S. 49° 37′ E. diſtance 208,4 mi
The courſe on larb. is S. 49° 37′ W. diſtance 208,4 m

QUESTION XX. *A ſhip that makes her way good within $6\frac{1}{2}$ points of e wind, is bound to a port bearing SW. b. S. $\frac{1}{4}$ W. diſtant 476 miles: ow the wind being at S. b. W. a current ſetting S. b. E. $2\frac{1}{4}$ miles an ur, and the ſhip ſailing $7\frac{1}{2}$ miles an hour: Required the courſe and ſtance ſhe muſt ſail on her ſtarboard and larboard tacks to gain the port?*

In the *SW. b. S.* $\frac{1}{4}$ *W.* rhumb, take AB = 476 miles; thro' A and B aw the lines AD, BD, in the directions of rhumbs $6\frac{1}{2}$ points from the nd, at *S. b. W.*; then, was there no current, the ſhip would ſail on e lines AD, DB.

With the run of the current *a* A = $2\frac{1}{4}$, and the run of the ſhip $7\frac{1}{2}$ les an hour, taken in rhumbs A *c*, A *d*, $6\frac{1}{2}$ points from the wind, com-at the parallelograms, whoſe diagonals *a c*, *a d*, ſhew the courſes the p will move in, with the compound motions of the current's and p's runs.

Then AC, BC, drawn parallel to *ad*, *ac*, will ſhew the run of the p on the ſtarboard and larboard tacks.

In the △ A *a d* are given A *a*, A *d*, ∠ *a* A *d*; to find the ∠ *d a* A = ° 41′.

In the △ A *a c* are given A *a*, A *c*, ∠ *a* A *c*; to find the ∠ *c a* A = 74° 54′.

Then CA *n* = ∠ *d a* A; ∠ *o* A *n* = ∠ *c a* A; and ∠BAC = (∠BA *n* ∠CA *n* =) 85° 30′.

Alſo ∠ *n* A *o* — ∠ *n* AB = ∠BA *o* = ∠ABC = 27° 05′. (183)

Then in the triangle ACB, there is known one ſide AC, and all the gles; by which the ſides AC, CB, may be found.

ANSWER { The courſe on the ſtarb. is S. 48° 56′ E. diſt. 234,7 miles.
The courſe on the larb. is S. 63° 39′ W. diſt. 514 miles.

Moſt of the Queſtions in the three preceding ſections, altho' not of ch common uſe at ſea, as thoſe in ſections the IVth and Vth, yet ve they their uſes on various occaſions, as will evidently appear from any of the queſtions themſelves: But there is another excellent uſe to derived from their ſolution, that does not appear at firſt ſight ſo evi-nt to *learners*, which is, the furniſhing them with an agreeable oppor-nity of exerciſing their talents in the application of Plane Trigono-etry: For it ſhould be well obſerved, that as all the operations rela-g to ſailing depend on the principles of Trigonometry, ſo the perſons, whom theſe principles are the moſt familiar, will with the greateſt adineſs not only apply them to the caſes of ſailing, but alſo ſee more early the reaſon of every ſtep they ſhall find themſelves neceſſitated to ke: And as a farther exerciſe for the underſtandings of thoſe who are ſirous of extending their notions this way, it has been thought proper annex the Queſtions in the following ſection with their ſolutions.

SECTION IX.

710. *A collection of practical queſtions.*

The figures belonging to the queſtions in this ſection are in Pl.
and numbered the ſame as the queſtions.

QUESTION I. *A ſhip in latitude 47° 30′ N. is bound to a port in titude 42° 00′ N. and 120 miles to the weſt, propoſes to reach her port running equal diſtances on each tack, the firſt to be on the meridian: W muſt the courſe be on the ſecond tack, and how far on each?*

SOLUTION. With the given difference of latitude = 330, and departure = 120, conſtruct the triangle ABC; from E, the middle of draw ED at right angles to AC: Then drawing DC, the lines AD, will be the diſtances the ſhip muſt run on each tack.

For ADC is by conſtruction an iſoſceles triangle. (1

In the triangle ABC, find the angles (341), ∠A = 19° 59′ = ∠AC the ∠ACB — ∠ACD = ∠DCB = 50° 02′; and 90° — ∠DCB = ∠BDC 39° 58′.

In the triangle CED, find (340) DC = 186,8.

ANSWER. The firſt courſe is S., the 2d S. 39° 58′ W.; and the on each tack 186,8 miles.

QUESTION II. *A ſhip having ſailed NE. b. E. from a port in lati 42° 18′ N., met a ſloop who had ſailed from a port in the ſame latitude, l 92 miles to the weſt of the ſhip's port: The ſum of their diſtances made miles: Required their reſpective courſes and diſtances?*

SOLUTION. In an eaſt and weſt line take BA = 92 m., from B draw the *NE. b. E.* rhumb BC = 159 m. join CA; then ED, drawn at ri angles to CA from E the middle, gives D, ſo that DA = DC. (1

In the triangle ABC, find (343) the ∠BAC = 114° 27′, and ∠ACI ∠CAD = 31° 47′.

Then ∠BAC — ∠CAD = ∠BAD = 82° 40′; hence ∠BDA = 63°

In the triangle BAD, find (340) BD = 101,9 miles, and AD = 57,7

ANSWER. The ſhip ſail'd NE. b. N. 101,9 miles, and the ſloop ſa N. 7° 20′ W. 57,7 miles.

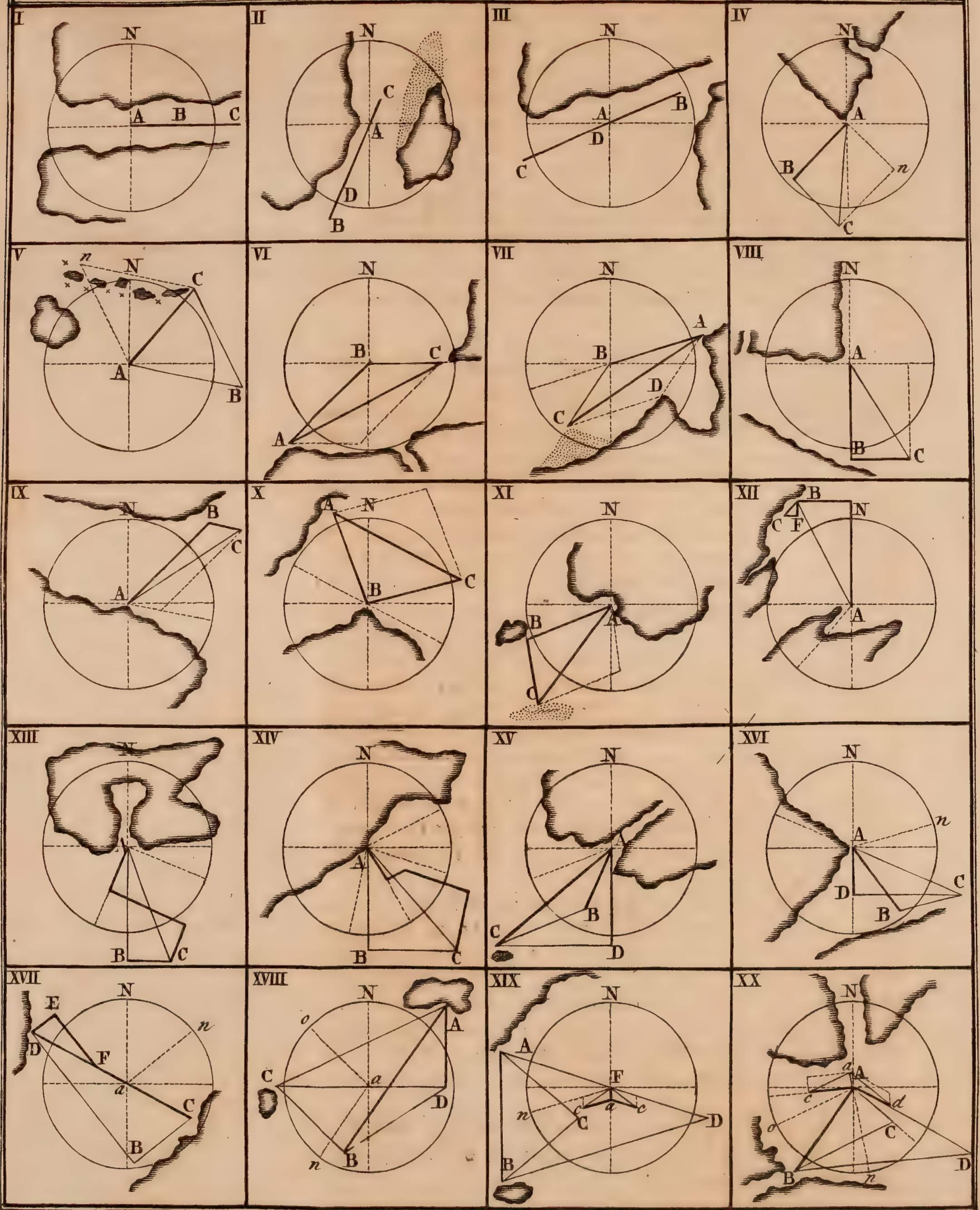
QUESTION III. *Two ſhips, A, B, ſail from one road, their cou making an angle of 50° 00′; A ſails between the S. and W. 40 leagues ſailing between the S. and E. 50 leagues, has got 15 leagues to the ſouthu of A: Required the courſe of each ſhip, alſo the bearing, diſtance and parture from A to B?*

SOLUTION. With the given ſides and included ∠A, conſtruct the angle ACB: On A, with 15 leagues, deſcribe an arc at D, and from the middle of AB, with the radius EA, cut the former arc in D (21 draw the given diff. lat. AD, and the required departure DB: Then the port ſailed from, A one ſhip's place, B the other's.

In the triangle ACB, find (343) the ∠CAB = 78° 24′, and ∠CBA 51° 56′; the ſide AB will be found 39,1 miles. In the triangle ADB, wl AB, AD, are known, find ∠DBA = 22° 34′, ∠DAB = 67° 26′, BD = 36,1.

ANSWER. A's courſe is S. 34° 10′ W. B's is S. 15° 10′E.; B bears f A S. 67° 26′ E. departure BD is 36,1 m. the diſt. A 39,1 miles.

SAILING IN CURRENTS. Pl.V.



T. Jefferys sculp.

Page 292.

Question IV. *From two ports bearing NW. b. N. and SE. b. S. wo ſhips ſail, the one NE. the other N. b. E.; they meet, and find that he ſum of their diſtances added to the diſtance of the ports made* 148 *miles: Required the diſtance of the ports, and the run of each ſhip?*

Solution. Make a triangle ADE equiangular to the triangle re-uired, wherein one ſide, as AD, ſhall be of any aſſigned length, as o, and by art. 340 find DE = 41,61; AE = 23,57; and the ſum of he three ſides of the triangle ADE will be 95,18: Then ſay,

As 95,18 : 148 : : AD = 30 : AC = 46,65.
And as 95,18 : 148 : : DE = 41,61 : CB = 64,70.

Then the other ſide AB will be 36,25 miles.

Answer { The diſtance of the ports is 36,25 miles.
One ſhip's run is 46,65 miles, the other's 64,7 miles.

Question V. *Two ſhips meet at ſea bound to two ports diſtant from ne another* 12 *miles; Now if one ſails NW. b. N.* 6 *miles an hour, and he other NE.* 8 *miles an hour, they will arrive at their reſpective ports at e ſame time: Required the diſtance each ſhip muſt run, and the bearing f thoſe ports from one another?*

Solution. With the courſes and rates of ſailing make the triangle DE, A repreſenting the place of meeting; parallel to DE draw AG = 2 miles; thro' G draw GC parallel to AD, meeting AE produced in C; hro' C draw CB parallel to AG, meeting AD produced in B; then B and are the ports. For AB : AC : : 6 : 8; and BC = 12 = AG, BG being a parallelogram.

In the triangle ADE, knowing AD, AE, and ∠A, find ∠D = 60° 30′, E = 40° 45′, and DE = 9,015 miles; then DE : BC : : AE : AC = 0,65; : : AD : AB = 7,988.

Answer { One runs NE. 10,65 miles; the other NW. b. N. 7,988 m.
C bears from B N. 85° 45′ E.

Question VI. *A fleet of ſhips ſteering SW. b. S.* 4 *miles an hour, on eing a ſail, detached a cruiſer, who gave chaſe SE.* 5 *hours at the rate of miles an hour, comes up with and takes the chace (being a privateer); and fter an hour's time ſpent in adjuſting matters on board the prize, ſhe ſteers or the fleet who ſtill kept on the ſame courſe and rate: Required the courſe he cruiſer muſt ſhape, and the diſtance ſhe muſt run at* 7 *miles an hour, to in them?*

Solutign. Let C be the firſt place of the fleet, draw CD, *SW. b. S.* nd CB, *SE.*; make CB = 35 (= 7 × 5), CA = 24 (= 4 × 6), and raw AB; then B is the place where the cruiſer took the chace, and A the lace where the fleet was when ſhe left the chace: Make AF = 4, FE = 7, draw BD parallel to FE, and D is the place where the cruiſer joined ne fleet.

In the triangle ACB, find ∠CAB = 63° 25′, and ∠CBA = 37° 49′, and B = 38,39. Then (181) ∠FAE = 116° 35′. In the triangle FAE, nd ∠E = 30° 44′, and ∠F = 32° 41′.

In the triangle ADB, ſimilar to AFE, find BD = 63,58 miles.

Answer. The cruiſer muſt ſteer S. 66° 26′ W. and run 63,58 miles.

QUESTION VII. *A ſhip on a WSW. courſe can ſail from the port* A *the port* B *in 6 days: But ſailing at the ſame rate by the log on a NE. b. courſe, ſhe goes from* B *to* A *in 3 days, a current all the way between ports ſetting eaſt, half a mile an hour: Required her dead reckoning o wards and homewards, alſo the bearing and diſtance of* A *from* B?

SOLUTION. In the 9 days outward and homeward bound, the c rent runs at ½ mile an hour, 108 miles eaſt, that is 72 m. for outwar and 36 homewards. In an eaſt and weſt line take AD = 36, D*d* = 7 thro' A draw a *WSW.* rhumb, and thro' *d* draw a *NE. b. N.* and *SW. b.* rhumb, continued to cut the former in E: Thro' D, E, draw paral to *d*E, *d*A, cutting in B; join AB, and draw BF parallel to EA, meet *d*A produced in F; then A and B repreſent the two ports, AE the o ward dead reckoning, BD the homeward, and AB the true diſtance.

For if AF = BE = D*d* = 72 is the drift of the current in the outw account, and the courſe ſhaped is along AE, the ſhip muſt run betw AF and AE: Alſo if BC = AD = 36 is the current's drift homeward, the courſe ſhaped is along BD, the ſhip muſt run between BG and B But AB is the only common diagonal to the parallelograms FE and D conſequently A and B are the ports.

In the triangle A*d*E, find (340) AE = 161,6 and E*d* = BD = 74,39

In the triangle ADB, find (343) ∠DAB = 39° 39′, and ∠DBA = 36′. Alſo (340) find AB = 99,04.

ANSWER { The dead reckoning outw. = 161,6 m. homew. = 74,39
The true courſe is S. 21° 21′ W.; diſtance 99,04 mile

QUESTION VIII. *A ſhip after doubling a cape and ſailing NE. b. 45 miles, receives in the night conſiderable damage from a ſtorm; ſhe t bore directly towards a lighthouſe lying 24 miles to the NW. of the cape, having run 40 miles, and the day breaking, ſhe diſcovers a port 42 mile the north of the cape: What was her courſe and diſtance to that port?*

SOLUTION. Draw AD *NE. b. N.* 45 m.; AB *N.* 42 m.; AC *N* 24 miles; join DC, make DE = 40 m. and draw AE, EB; then A is cape, C the lighthouſe, and B the port.

In the triangle CAD with the given ſides and included angle A, fi the ∠C = 70° 58½′, ∠D = 30° 16½′, and the ſide CD = 46,69 mile

In the triangle ADE with the given ſides and included angle D, find ∠DEA = 87° 08′, ∠DAE = 62° 36′, and AE = 22,71 miles.

In the triangle BAE with the known ſides AB, AE, and inclu ∠EAB, find ∠BEA = 124° 47′, ∠B = 26° 22′, and EB = 24,67 mile

ANSWER { The courſe from E to B is N. 26° 22′ E.
And the diſtance EB is 24,67 miles.

QUESTION IX. *A ſhip running at the rate of $4\frac{1}{2}$ miles an hour, with e wind, then at E. b. N. blowing two points abaft the beam; at 5 in the ening, being 2 leagues to the W. b. S. of a headland, ſhe met the tide of od ſetting SSW. at the rate of $1\frac{3}{4}$ miles an hour; and at 9 that evening, lighthouſe, which lay to the NNE. $\frac{1}{2}$ E. of the headland, bore ENE. $\frac{3}{4}$ E.: equired the ſhip's courſe aud her diſtance from the lighthouſe?*

SOLUTION. From 5 to 9 is 4 hours, in which time the ſhip runs 18 iles, and the tide 7 miles: Alſo 2 points abaft the beam, or 10 points om the wind, is *NW. b. N.*

Suppoſe the ſhip at A; then in the *E. b. N.* rhumb take AE = 6, and is the headland; in the *NW. b. N.* take AB = 18; thro' B draw BC rallel to the *SSW.* rhumb, and equal to 7, join CA, CE; thro' E draw *NNE.* $\frac{1}{2}$ *E.* rhumb, meeting in D a *ENE.* $\frac{3}{4}$ *E.* rhumb drawn from Then C is the ſhip's place at laſt, AC her real run, and D the place the lighthouſe.

In the triangle ABC, where two ſides, AB, BC, and the included ∠B, : known; find ∠BCA = 101° 19′; ∠BAC = 22° 25′, and the ſide AC 15,26 miles.

In the triangle CAE, where are known AE = 6, AC = 15,26, ∠CAE 134° 55′; find ∠AEC = 32° 47′, ∠ACE = 12° 18′, and the ſide = 19,94 miles.

In the triangle CED, where are known CE = 19,94 m. ∠D = 47° ′, ∠DCE = 35° 36′, and ∠DEC = 96° 35′; the ſide ED will be found ,67 miles, and the ſide CD = 26,74 miles.

ANSWER. The ſhip's true courſe is N. 56° 10′ W.; diſt. from the lighthouſe 26,74 miles.

QUESTION X. *Two ſhips departed from a port at the ſame time, er one had ſailed SE. b. E. 40 miles, and the other SW. 50 miles, they re equally diſtant from a rock lying directly ſouth of their port: Required ir bearing and diſtance from the rock?*

SOLUTION. From A the port, draw AB *SW.* 50 miles, AC *SE. b. E.* miles, join BC, and from F, the middle thereof, draw at right angles t BC, the line FD meeting the meridian in D, the place of the rock, a join DB, DC, which are equal by art. 193.

In the triangle BAC, where are known AB = 50, AC = 40, ∠BAC = 101° 15′; find ∠ACB = 44° 35′, ∠ABC = 34° 10′, and BC = 69,86 les.

In the triangle AEC, where are known AC = 40, ∠EAC = 56° 15′, ∠ACE = 44° 35′, ∠AEC = 79° 10′; find EC = 33,86 miles.

Then CF = ($\frac{1}{2}$ BC) − EC = FE = 1,07.

In the right angled triangle FED, where are known FE = 1,07, and ∠ED = 79° 10′; find the ſide DF = 5,591.

n the right angled triangle DFC, where DF = 5,591, FC = 34,93; fi the ∠FDC = 80° 54′, and DC = 35,38 miles.

ANSWER { The ſhip at B is 35,38 miles to the S. 88° 16′ W. the rock.
The ſhip at C is 35,38 miles to the N. 70° 04′ E. the rock.

QUESTION XI. *Sailing E. b. S. with a briſk gale $7\frac{1}{2}$ knots an hour, ſaw two iſlands, one bearing SE. b. S. the other E. b. N.; the tide w then running SW. b. W. $2\frac{1}{2}$ miles an hour: Two hours after, the firſt iſl bore W. b. S. and the other NW. b. N.: Required the ſhip's courſe and d tance, together with the bearing and diſtance of thoſe iſlands from one anothe*

SOLUTION. In an *E. b. S.* rhumb, take AC = 15 miles, (= $7\frac{1}{2}$ × 2); thro' A draw AB, AE, parallel to the *E. b. N.* and *SE. b. S.* rhumt draw CD *SW. b. S.* and equal to 5 miles, which the tide runs in t hours; thro' D lines being drawn parallel to the *NW. b. N.* and *W. b.* rhumbs, their interſections with AB, AE, give E, the place of one iſlar and B, the place of the other; join AD, BE.

In the triangle ADC, where AC = 15, DC = 5, and ∠ACD = 45° 0 find the ∠CDA = 117° 52′, ∠CAD = 17° 08′, and AD = 12 miles.

Now as ED is parallel to AB, and BD parallel to AE, therefore AB is a parallelogram; and ſo AB = ED, AE = BD.

In the triangle AED, where AD = 12 miles, ∠AED = 112° 3 ∠DAE = 27° 52′, and ∠ADE = 39° 38′; find AE = 8,286 miles, a ED = 6,072 miles.

In the triangle ABE, where AE = 8,286 miles, AB = 6,072 mil and ∠EAB = 67° 30′; find ∠ABE = 69° 15′, the ∠AEB = 43° 1 and the ſide BE = 8,186 miles.

ANSWER { The ſhip's courſe was S. 61° 37′ E. diſtance 12 miles.
The *N.* iſland bore from the *S.* iſle, N. 9°30′E. diſt. 8,186

QUESTION XII. *Coming out of port into which the tide of flood w then ſetting, I ſaw two headlands; the northern one, which bore ENE. $\frac{1}{2}$ was known to be 15 miles to the NNE. $\frac{1}{2}$ E. of the other, which then b S. b. E.: After running E. b. S. $\frac{1}{2}$ E. 24 miles by the log, the northern hea land bore NW. and the other W. b. S.: Required the ſetting and drift the tide?*

SOLUTION. In a *NNE.* $\frac{1}{2}$ *E.* rhumb take AB = 15 miles; thro' draw AC *N. b. W.* and AD *E. b. N.*; alſo thro' B draw BC *WSW.* $\frac{1}{2}$ *V* and BD *SW.*; then C, the interſection of AC, BC, is the ſhip's place firſt, and D, the meeting of BD and AD, is the ſhip's place at laſ From C draw an *E. b. S.* $\frac{1}{2}$ *E.* rhumb CE = 24 miles, and draw AD, ED

In the triangle ABC, where AB = 15 miles, ∠ACB = 95° 38′, a the ∠CBA = 45° 00′; find AC = 10,66 miles.

In the triangle ABD, where AB = 15 miles, ∠ADB = 56° 15′, a the ∠ABD = 73° 08′; find AD = 17,26 miles.

In the right angled triangle CAD, where AC = 10,66, and AD 17,26; find ∠ACD = 58° 19′, ∠ADC = 31° 41′, and CD = 20,29

In the triangle CDE, where CE = 24, CD = 20,29, and ∠DCE 14° 49′; find ∠CDE = 112,29, ∠CED = 52° 42′, and DE = 6,522

ANSWER. The tide ſet S. 42° 55′ W. and its drift is 6,522 mil

QUESTION XIII. *A ſhip running 5 knots an hour diſcovers Scilly ights bearing NE. b. N. diſtant 6 leagues, the flood tide being juſt made, nd ſetting ENE. 2 miles an hour: Required what courſe ſhe muſt ſteer, nd how far by the log, to bring herſelf 5 leagues to the ſouth of the Lizard, which lies 11 leagues to the E. b. N. $\frac{1}{2}$ E. of Scilly?*

SOLUTION. Draw SL *E. b. N.* $\frac{1}{2}$ *E.* 33 miles, LE *S.* 15 miles, and SA *W. b. S.* 18 miles; join SE, AE: Draw AB *ENE.* 2 miles, and on B ith BC = 5 miles cut AE in C, join BC; draw AD parallel to EC, and D parallel to AB; then A repreſents the ſhip's place at firſt, S Scilly, the Lizard, E the ſhip's place at laſt, and AD the rhumb and diſtance e muſt fail.

In the triangle SLE, where SL = 33 miles, LE = 15, and the ∠SLE = 84° 22′; find ∠LES = 70° 18′, ∠LSE = 25° 20′, and SE = 34,89 m.

In the triangle ASE, where AS = 18, SE = 34,89, and the ∠ASE = 4° 02′; find ∠SAE = 51° 59′, ∠SEA = 23° 59′, and AE = 42,96 m.

In the triangle ABC, where AB = 2, BC = 5, and ∠BAC = 18° 14′; d ∠C = 7° 11′.

Now in the triangle ADE, ſimilar to the triangle ABC, are known E = 42,96 miles, ∠DAE = 7° 11′, ∠AED = 18° 14′, and the ∠D = 4° 35′; hence the ſide AD will be found = 31,32 miles.

ANSWER. The ſhip muſt fail S. 87° 05′ E. diſtance 31,32 miles.

QUESTION XIV. *At 6 o'clock in the evening a privateer ſaw a ſhip ectly to windward bearing NE. about 3 leagues diſtance, they were both ſe hauled on their ſtarboard tacks; the privateer having ſailed 18 miles, 9 o'clock the ſhip bore E. b. N. $\frac{1}{2}$ E.: Now the privateer finding he got head, would ſpeak with the ſhip at 2 o'clock in the morning: Required at hat rate the privateer muſt ſail, and at what time tack about, keeping 6 nts from the wind, ſuppoſing the other ſhip does not alter her courſe and e of failing?*

SOLUTION. Six points from the wind at *NE.* on ſtarb. tacks is *NNW.*; n in a line AF parallel to a *NNW.* rhumb take AC = 18 m. draw AI *NE.* which take AB = 9; alſo BG = 3, GI = 5, repreſenting the times between nd 9, and 9 and 2 o'clock; draw BE parallel to AF, and thro' C draw an *b. N.* $\frac{1}{2}$ *E.* rhumb CD; join DG, draw IE parallel to DG; thro' E draw F 6 points from the wind, and join EC, CB: Then the privateer tack- at F, will meet the ſhip at E.

In the triangle ABC, find ∠ABC = 82° 46′, ∠ACB = 29° 44′, and CB = 16,76.

In the triangle CBD, find BD = 12,04, and DC = 8,689.

Then BG : GI :: BD : DE = 20,07 miles the ſhip fails from 9 to 2.

n the triangle CDE, find ∠C = 81° 31′, ∠E = 25° 21′, and EC = 42 miles.

n the triangle CEF, find FE = 11,76, and FC = 25,87 miles.

Now FE + FC = 37,63 m., which run in 5 hours, is 7,12 m. an hour.

And FC at 7,12 m. per hour gives 3 h. 37 m. 48 ſ. after 9 o'clock.

ANSWER. The privateer muſt tack at 12 h. 37 m. 48 ſ. and fail 7,12 mes an hour.

QUESTION XV. *Two ſhips ſteering between the S. and W. parted co pany in latitude 20° 15′ N. one going $2\frac{3}{4}$ points more weſterly than the othe next day at noon they arrived at two ports in latitude 19° 16′ N. and diſt 45 miles: Required the courſe and diſtance which each ſhip ſailed after t parted?*

SOLUTION. In an eaſt and weſt line take CB = 45 miles; on deſcribe (180) the ſegment CBA of a circle that ſhall contain an an equal to 30° 56′ = $2\frac{3}{4}$ points; in the meridian take BH = 59 miles, diff. lat.; thro' H draw HA parallel to CB, meeting the circle CBA in draw AF parallel to HB, meeting CB produced in F, join AB, AC, a from E the centre of the circle CBA, draw EA, EB; EG parallel to and ED parallel to BH.

In the right angled triangle EBD, where ∠DEB = (∠CAB =) 30° 5 and DB = 22,5 miles; find ED = FG = 37,54, and EB = EA = 43,77

In the right angled triangle AEG; find ∠AEG = 29° 22′, and EG = 38,

In the right angled triangle AFB, where AF = 59 miles, BF = (= EG) — DB = 15,65; find ∠BAF = 14° 51′, and AB = 61,06 mil

In the right angled triangle AFC, where AF = 59, CF = CB + BF 60,65 miles, and ∠CAF = 45° 47′; find AC = 84,62 miles.

ANSWER { The courſe of one ſhip is S. 14° 51′ W. diſt. 61,06 mil
The courſe of the other is S. 45° 47′ W. diſt. 84,62 mil

QUESTION XVI. *Two ſhips,* A *and* B, *both going at the rate of 6 kn an hour, parted company in the latitude of 45° N.* A *ſteering in the N and* B *in the NW. quarter; next day at noon they both arrived at their po* A *in lat. 45° 58′ N.* B *in lat. 45° 36′ N. and the ſum of their departu was 64 miles: At what hour did they part, and what was the courſe diſtance each ſhip had ſailed?*

SOLUTION. Make the departures FG = 64 miles, the diff. lat. FB 58, and GC = 36 miles; draw BC, and from K, the middle of BC, dr at right angles to BC, HE, meeting FG in A, and BF produced in join AC, AB; then draw AH parallel to FB, and CD, BH parallel to F meeting AH in I and H.

In the right angled triangle BDC, where DC = 64, DB = 22; fi ∠DBC = 71° 02′, ∠DCB = 18° 58′, and BC = 67,69 miles: Hence = KC = 33,84.

In the right angled triangle BKE, where ∠E = 18° 58′, ∠KBE 71° 02′, and KB = 33,84 miles; find BE = 104,1: Hence BE — BF FE = 46,1 miles.

In the right angled triangle EFA, find FA = 15,84 miles: Hence = 48,16.

In the right angled triangle AIC, where AI = (GC =) 36, IC = 48,1 find ∠IAC = 53° 13′, and AC = 60,13 miles.

In the right angled triangle AHB, find ∠BAH = 15° 17′.

Now AC or AB = 60,13 divided by 6 gives 10,02 hours = 10 h. 2 m. 1

ANSWER { The ſhips parted at 1 h. 58 m. 48 ſ. in the morning.
A's courſe is N. 15° 17′ W, B's is N. 53° 13′ E.; diſt. each is 60,13 mil

QUESTI

QUESTION XVII. *Paſſing by a rock lying off the mouth of a harbour hoſe breadth is* 12 *miles, the weſtern point thereof bearing NNW. is* 9 *miles ſtant from the town; and the eaſtern point of the mouth bearing NE. b. N.* 6 *miles from the town: Required the diſtance of the rock from the weſtern d eaſtern points, and alſo from the town which bore N. b. E.?*

SOLUTION. With the three given ſides, 12, 9, 6, having conſtructed riangle where A and C are the weſtern and eaſtern points of the har- ur's mouth, and B the town; make the $\angle ACD = 3$ points, $= \angle$ be- een the bearings of A and B; alſo make the $\angle CAD = 2$ points $= \angle$ ween the bearings of C and B; thro' ADC deſcribe a circle; then the ht line BDF being drawn will give in the circumference the point F, place of the rock.

FOR the $\angle AFD = \angle ACD = 3$ points; and $\angle CFD = \angle CAD = 2$ pts. (212)

In the triangle ABC, find $\angle BAC = 28^\circ\ 57'$, the $\angle BCA = 46^\circ\ 33'$, l the $\angle ABC = 104^\circ\ 30'$.

In the triangle ACD, where $\angle ADC = 123^\circ\ 45'$, $\angle DCA = 3$ points, AC $= 2$ points, find DA $= 8{,}018$ miles.

n the triangle ADB, where AB $= 9$, AD $= 8{,}018$, and $\angle BAD = 6^\circ$; find the $\angle ABD = 41^\circ\ 05\frac{1}{2}'$: Hence $\angle CBD = 63^\circ\ 24'$.

n the triangle ABF, find AF $= 10{,}65$ miles, and FB $= 15{,}64$ miles.

n the triangle FBC, find FC $= 14{,}02$ miles.

ANSWER. FA $= 10{,}65$, FB $= 15{,}64$, FC $= 14{,}02$ miles.

QUESTION XVIII. *At night caſting anchor among a cluſter of iſlands, bſerved three lighthouſes* A, B, C; A *bore NNE.* B *bore SSE.* $\frac{1}{2}$ *E. and ore eaſt; the diſtance from* A *to* B *is* 94 *miles, from* B *to* C 78 *miles, from* A *to* C *is* 59 *miles: Required my diſtance from each lighthouſe?*

SOLUTION. Let ABC be the triangle formed by the diſtances of the e lighthouſes; on CB, CA, deſcribe (180) ſegments of circles that ll contain the angles included between the bearings of C and B, and and A; and the interſection D of theſe circles, is the point where ſhip caſt anchor: Thro' the centres H, K, draw aE, bG, at right les to CB, CA; and draw EB, EC; HB, HC; GC, GA; KC, KA; join KH cutting CD in m.

Now becauſe CD is a chord common to both circles, therefore HK bi- ſes CD in m: Alſo, becauſe $\angle CDB$ and $\angle CEB$ together are meaſured by the circle (211); therefore $\angle CEB = 180^\circ - \angle CDB$; and for the e reaſon, the $\angle CGA = 180^\circ - \angle CDA$; therefore the $\angle$ s. CEB, CGA, known; and (210) ſo are their equals $\angle CHa = 61^\circ\ 52\frac{1}{2}'$, $CKb =$ $30'$.

n the triangle CAB, from the given ſides find $\angle CAB = 55^\circ\ 48'$, $\angle$BA $= 38^\circ\ 44'$, and the $\angle ACB = 85^\circ\ 28'$.

n the right angled triangle CaH, where C$a = 39$ m. $\angle CHa = 61^\circ$ $'$; find CH $= 44{,}22$ miles.

the right angled triangle CbK, where C$b = 29\frac{1}{2}$ m. $\angle CKb =$ $30'$; find CK $= 31{,}93$ miles.

In the triangle KCH, where KC = 31,93, CH = 44,22, the ∠K = 136° 06′ (= ∠KCA + ∠ACB + ∠BCH); find ∠CKH = 25° 4 and ∠CHK = 18° 14′.

In the right angled triangle CH *m*, where ∠CH *m* = 18° 14′, and = 44,22 m.; find C *m* = 13,84 miles, which doubled gives CD = 27, miles.

In the triangle ACD, where CD = 27,68 m. ∠CAD = 25° 40½′, a ∠ACD = 41° 49½′; find AD = 42,6 miles.

In the triangle ADB, where AB = 94 miles, ∠BDA = 129° 22 ∠DAB = 30° 07½′; find DB = 61,03 miles.

ANSWER. The diſtance from D to
- A is 42,6 miles.
- B is 61,03 miles.
- C is 27,68 miles.

QUESTION XIX. *In latitude* 48° 50′ *N. we were attacked by a private who upon receiving our broadſide lay to, and we ſtood away NNW.; ſ time after the privateer bore away NE. b. N. and two hours after, having by our eſtimation run* 10 *miles, was* 7 *miles directly eaſt of u Now by our account we had ſailed* 4 *leagues ſince the action, and the tide the time has run two miles an hour: Required the ſetting of the tide, time the privateer lay to, our rate of ſailing, and each ſhip's direct courſe a diſtance?*

SOLUTION. Suppoſe the action at A, then parallel to the *NN* and *NE. b. N.* rhumbs, draw AB = 12 m. AC = 10 m. and join B thro' C draw CD = 7 miles due weſt; join BD, and in this line produc take DI = 4 miles the tide's drift in 2 hours; draw CF parallel and eq to DI; thro' F draw a weſt line FG, meeting BI in I, and a meridi thro' A, in G; and draw AF, AI, which repreſent the runs of the t ſhips, F being the place of the privateer when ſhe was 7 miles eaſt of t other ſhip then at I.

In the triangle ABC, where AB = 12, AC = 10, and ∠BAC = 5 15′; find ∠ACB = 71° 31½′, ∠ABC = 52° 13½′, and BC = 10,52 mil

In the triangle BCD, where BC = 10,52 m. CD = 7 m. ∠BCD = 1 16½′ (= 71° 31½′ — 56° 15′); find ∠BDC = 138° 40′, ∠DBC = 26° 0 and BD = 4,197 miles, which is the tide's run while the privateer lay b

In the triangle ACF, where CA = 10 m. CF = 4 m. and ∠ACF = 8 25′ (= ∠DCF — ∠DCA); find ∠AFC = 74° 52½′, ∠CAF = 22° 42½′, a AF = 10,27 miles, the diſtance ſailed by the privateer.

In the right angled triangle AGF, where AF = 10,27, the ∠FAG (∠GAC + ∠CAF =) 56° 27½′; find AG = 5,675, and GF = 8,5 miles.

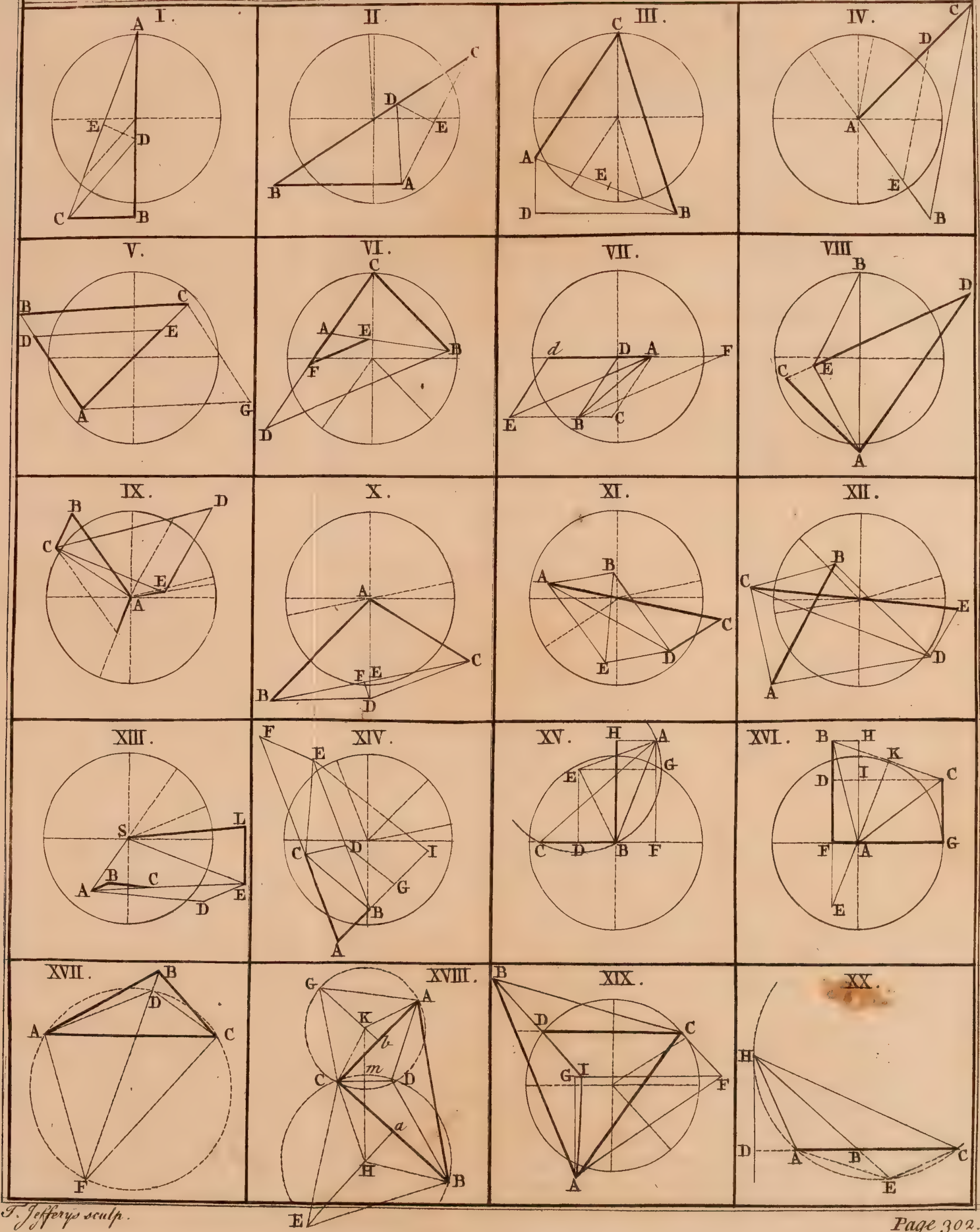
In the right angled triangle AGI, where AG = 5,675, GI = (GF IF =) 1,561; find ∠GAI = 15° 23′, and AI = 5,886 miles.

Now 4,197 m. divided by 2 m. per hour, gives 2,098 h. = 2 h. 5 52 ſ.

ANSWER
- The privateer lay by 2 h. 5 m. 52 ſ. nearly.
- The tide ſets S. 48° 40′ E.
- The privateer ſailed N. 56° 27′ E. diſtance 10,27 mile
- The other ſhip ſailed N. 15° 23′ E. diſtance 5,886 mile

QUESTI

PRACTICAL QUESTIONS. Pl. VI.



T. Jefferys sculp.

Page 302.

11. A TRAVERSE TABLE

To every POINT and QUARTER POINT of the

COMPASS or HORIZON:

In FOUR PAGES.

AND ALSO

12. A TRAVERSE TABLE

To every DEGREE and QUARTER DEGREE of the

COMPASS or HORIZON:

In FORTY-FIVE PAGES.

Distance	0 Points						1 Point								2
	¼		½		¾		0		¼		½		¾		0
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat
1	1,00	0,05	0,99	0,10	0,99	0,15	0,98	0,20	0,97	0,24	0,96	0,29	0,94	0,34	0,9
2	2,00	0,10	1,99	0,20	1,98	0,29	1,96	0,39	1,94	0,49	1,91	0,58	1,88	0,67	1,8
3	3,00	0,15	2,99	0,29	2,97	0,44	2,94	0,59	2,91	0,73	2,87	0,87	2,82	1,01	2,7
4	4,00	0,20	3,98	0,39	3,96	0,59	3,92	0,78	3,88	0,97	3,83	1,16	3,77	1,35	3,7
5	4,99	0,25	4,98	0,49	4,95	0,73	4,90	0,98	4,85	1,21	4,78	1,45	4,71	1,68	4,6
6	5,99	0,29	5,97	0,59	5,93	0,88	5,89	1,17	5,82	1,46	5,74	1,74	5,65	2,02	5,5
7	6,99	0,34	6,97	0,69	6,92	1,03	6,87	1,37	6,79	1,70	6,70	2,03	6,59	2,36	6,4
8	7,99	0,39	7,96	0,78	7,91	1,17	7,85	1,56	7,76	1,94	7,66	2,32	7,53	2,69	7,3
9	8,99	0,44	8,96	0,88	8,90	1,32	8,83	1,76	8,73	2,19	8,61	2,61	8,47	3,03	8,3
10	9,99	0,49	9,95	0,98	9,89	1,47	9,81	1,95	9,70	2,43	9,57	2,90	9,42	3,37	9,2
11	10,99	0,54	10,95	1,08	10,88	1,63	10,79	2,15	10,67	2,67	10,53	3,19	10,36	3,71	10,1
12	11,99	0,59	11,94	1,18	11,87	1,76	11,77	2,34	11,64	2,92	11,48	3,48	11,30	4,04	11,
13	12,98	0,64	12,94	1,27	12,86	1,91	12,75	2,54	12,61	3,16	12,44	3,77	12,24	4,38	12,01
14	13,98	0,69	13,93	1,37	13,85	2,05	13,73	2,73	13,58	3,40	13,40	4,06	13,18	4,72	12,9
15	14,98	0,74	14,93	1,47	14,84	2,20	14,71	2,93	14,55	3,64	14,35	4,35	14,12	5,05	13,8
16	15,98	0,79	15,92	1,57	15,83	2,35	15,69	3,12	15,52	3,89	15,31	4,64	15,06	5,39	14,7
17	16,98	0,84	16,92	1,67	16,82	2,49	16,67	3,32	16,49	4,13	16,27	4,93	16,01	5,73	15,7
18	17,98	0,88	17,91	1,76	17,81	2,64	17,65	3,51	17,46	4,37	17,22	5,22	16,95	6,06	16,6
19	18,98	0,93	18,91	1,86	18,79	2,79	18,64	3,71	18,43	4,62	18,18	5,51	17,89	6,40	17,5
20	19,98	0,98	19,90	1,96	19,78	2,93	19,62	3,90	19,40	4,86	19,14	5,81	18,83	6,74	18,4
21	20,98	1,03	20,90	2,06	20,77	3,08	20,60	4,10	20,37	5,10	20,10	6,10	19,77	7,07	19,40
22	21,97	1,08	21,89	2,16	21,76	3,23	21,58	4,29	21,34	5,35	21,05	6,39	20,71	7,41	20,33
23	22,97	1,13	22,89	2,25	22,75	3,37	22,56	4,49	22,31	5,59	22,01	6,68	21,65	7,75	21,25
24	23,97	1,18	23,88	2,35	23,74	3,52	23,54	4,68	23,28	5,83	22,97	6,97	22,60	8,08	22,17
25	24,97	1,23	24,88	2,45	24,73	3,67	24,52	4,88	24,25	6,07	23,92	7,26	23,54	8,42	23,10
26	25,97	1,28	25,87	2,55	25,72	3,81	25,50	5,07	25,22	6,32	24,88	7,55	24,48	8,76	24,02
27	26,97	1,33	26,87	2,65	26,71	3,96	26,48	5,27	26,19	6,56	25,84	7,84	25,42	9,10	24,95
28	27,97	1,37	27,87	2,74	27,70	4,11	27,46	5,46	27,16	6,80	26,79	8,13	26,36	9,43	25,87
29	28,97	1,42	28,86	2,84	28,69	4,25	28,44	5,66	28,13	7,05	27,75	8,42	27,30	9,77	26,79
30	29,96	1,47	29,85	2,94	29,67	4,40	29,42	5,85	29,10	7,29	28,71	8,71	28,25	10,11	27,72
31	30,96	1,52	30,85	3,04	30,66	4,55	30,41	6,05	30,07	7,53	29,66	9,00	29,19	10,44	28,64
32	31,96	1,57	31,84	3,14	31,65	4,70	31,39	6,24	31,04	7,77	30,62	9,29	30,13	10,78	29,56
33	32,96	1,62	32,84	3,23	32,64	4,84	32,37	6,44	32,01	8,02	31,58	9,58	31,07	11,12	30,49
34	33,96	1,67	33,84	3,33	33,63	4,99	33,35	6,63	32,98	8,26	32,54	9,87	32,01	11,45	31,41
35	34,96	1,72	34,83	3,43	34,62	5,14	34,33	6,83	33,95	8,50	33,49	10,16	32,95	11,79	32,34
36	35,96	1,77	35,83	3,53	35,61	5,28	35,31	7,02	34,92	8,75	34,45	10,45	33,90	12,13	33,26
37	36,95	1,82	36,82	3,63	36,60	5,43	36,29	7,22	35,89	8,99	35,41	10,74	34,84	12,46	34,18
38	37,95	1,87	37,82	3,72	37,59	5,58	37,27	7,41	36,86	9,23	36,36	11,03	35,78	12,80	35,11
39	38,95	1,91	38,81	3,82	38,58	5,72	38,25	7,61	37,83	9,48	37,32	11,32	36,72	13,14	36,03
40	39,95	1,96	39,81	3,92	39,57	5,87	39,23	7,80	38,80	9,72	38,28	11,61	37,66	13,48	36,96
41	40,95	2,01	40,80	4,02	40,56	6,02	40,21	8,00	39,77	9,96	39,23	11,90	38,60	13,81	37,88
42	41,95	2,06	41,80	4,12	41,54	6,16	41,19	8,19	40,74	10,20	40,19	12,19	39,54	14,15	38,80
43	42,95	2,11	42,79	4,21	42,53	6,31	42,17	8,39	41,71	10,45	41,15	12,48	40,49	14,49	39,73
44	43,95	2,16	43,79	4,31	43,52	6,46	43,16	8,58	42,68	10,69	42,11	12,77	41,43	14,83	40,65
45	44,95	2,21	44,78	4,41	44,51	6,60	44,14	8,78	43,65	10,93	43,06	13,06	42,37	15,16	41,57
46	45,95	2,26	45,78	4,51	45,50	6,75	45,12	8,97	44,62	11,18	44,02	13,35	43,31	15,50	42,50
47	46,94	2,31	46,77	4,61	46,49	6,90	46,10	9,17	45,59	11,42	44,98	13,64	44,25	15,83	43,42
48	47,94	2,36	47,77	4,70	47,48	7,04	47,08	9,37	46,56	11,66	45,93	13,93	45,19	16,17	44,35
49	48,94	2,41	48,76	4,80	48,47	7,19	48,06	9,56	47,53	11,91	46,89	14,22	46,14	16,51	45,27
50	49,94	2,45	49,76	4,90	49,46	7,34	49,04	9,75	48,50	12,15	47,85	14,51	47,08	16,84	46,19
51	50,94	2,50	50,75	5,00	50,45	7,48	50,02	9,95	49,47	12,39	48,80	14,80	48,02	17,18	47,12
52	51,04	2,55	51,75	5,10	51,44	7,63	51,00	10,14	50,44	12,63	49,76	15,09	48,96	17,52	48,04
53	52,94	2,60	52,74	5,19	52,43	7,78	51,98	10,34	51,41	12,88	50,72	15,38	49,90	17,86	48,97
54	53,94	2,65	53,74	5,29	53,41	7,92	52,96	10,54	52,38	13,12	51,67	15,67	50,84	18,19	49,89
55	54,93	2,70	54,73	5,39	54,40	8,07	53,94	10,73	53,35	13,36	52,63	15,96	51,78	18,53	50,81
56	55,93	2,75	55,73	5,49	55,39	8,22	54,92	10,92	54,32	13,61	53,59	16,26	52,73	18,87	51,74
57	56,93	2,80	56,72	5,59	56,38	8,36	55,91	11,12	55,29	13,85	54,55	16,54	53,67	19,20	52,66
58	57,93	2,85	57,72	5,68	57,37	8,51	56,89	11,31	56,26	14,09	55,50	16,84	54,61	19,54	53,59
59	58,93	2,90	58,72	5,78	58,36	8,66	57,87	11,51	57,23	14,34	56,45	17,13	55,55	19,88	54,51
60	59,93	2,94	59,71	5,88	59,35	8,80	58,85	11,71	58,20	14,58	57,42	17,42	56,49	20,21	55,43
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	¾		½		¼		0		¾		½		¼		0
	7 Points								6 Points						

0 Points						1 Point								2 Points		Diſtance
¼		½		¾		0		¼		½		¾		0		
at.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
,93	2,99	60,71	5,98	60,34	8,95	59,83	11,90	59,17	14,82	58,37	17,71	57,43	20,55	56,36	23,34	61
,93	3,04	61,70	6,08	61,33	9,10	60,81	12,09	60,14	15,06	59,33	18,00	58,38	20,89	57,28	23,73	62
,92	3,09	62,70	6,17	62,32	9,24	61,79	12,29	61,11	15,31	60,29	18,29	59,32	21,22	58,21	24,11	63
,92	3,14	63,69	6,27	63,31	9,39	62,77	12,48	62,08	15,55	61,24	18,58	60,26	21,56	59,13	24,49	64
,92	3,19	64,69	6,37	64,30	9,54	63,75	12,68	63,05	15,79	62,20	18,87	61,20	21,90	60,05	24,87	65
,92	3,24	65,68	6,47	65,28	9,68	64,73	12,88	64,02	16,04	63,16	19,16	62,14	22,23	60,98	25,26	66
,92	3,29	66,68	6,57	66,27	9,83	65,71	13,07	64,99	16,28	64,11	19,45	63,08	22,57	61,90	25,64	67
,92	3,34	67,67	6,66	67,26	9,98	66,69	13,27	65,96	16,52	65,07	19,74	64,02	22,91	62,82	26,02	68
,92	3,39	68,67	6,76	68,25	10,12	67,67	13,46	66,93	16,77	66,03	20,03	64,97	23,24	63,75	26,40	69
,92	3,44	69,66	6,86	69,24	10,27	68,66	13,66	67,90	17,01	66,99	20,32	65,91	23,58	64,67	26,79	70
,92	3,48	70,66	6,96	70,23	10,42	69,64	13,85	68,87	17,25	67,94	20,61	66,85	23,92	65,60	27,17	71
,91	3,53	71,65	7,06	71,22	10,56	70,62	14,05	69,84	17,49	68,90	20,90	67,79	24,26	66,52	27,55	72
,91	3,58	72,65	7,15	72,21	10,71	71,60	14,24	70,81	17,74	69,86	21,19	68,73	24,59	67,44	27,94	73
,91	3,63	73,64	7,25	73,20	10,86	72,58	14,44	71,78	17,98	70,81	21,48	69,67	24,93	68,37	28,32	74
,91	3,68	74,64	7,35	74,19	11,00	73,56	14,63	72,75	18,22	71,77	21,77	70,62	25,27	69,29	28,70	75
,91	3,73	75,63	7,45	75,18	11,15	74,54	14,83	73,72	18,47	72,73	22,06	71,56	25,60	70,21	29,08	76
,91	3,78	76,63	7,55	76,17	11,30	75,52	15,02	74,69	18,71	73,68	22,35	72,50	25,94	71,14	29,47	77
,91	3,83	77,62	7,64	77,15	11,45	76,50	15,22	75,66	18,95	74,64	22,64	73,44	26,28	72,06	29,85	78
,91	3,88	78,62	7,74	78,14	11,59	77,48	15,41	76,63	19,20	75,60	22,93	74,38	26,61	72,99	30,23	79
,90	3,93	79 61	7,84	79,13	11,74	78,46	15,61	77,60	19,44	76,55	23,22	75,32	26,95	73,91	30,61	80
,90	3,98	80,61	7,94	80,12	11,88	79,44	15,80	78,57	19,68	77,51	23,51	76,27	27,29	74,83	31,00	81
,90	4,02	81,60	8,04	81,11	12,03	80,43	16,00	79,54	19,92	78,47	23,80	77,21	27,62	75,76	31,38	82
,90	4,07	82,60	8,14	82,10	12,18	81,41	16,19	80,51	20,17	79,43	24,09	78,15	27,96	76,68	31,76	83
,90	4,12	83,59	8,23	83,09	12,32	82,39	16,39	81,48	20,41	80,38	24,38	79,09	28,30	77,61	32,14	84
,90	4,17	84,59	8,33	84,08	12,47	83,37	16,58	82,45	20,65	81,34	24,67	80,03	28,63	78,53	32,53	85
,90	4,22	85,58	8,43	85,07	12,62	84,35	16,78	83,42	20,90	82,30	24,96	80,97	28,97	79,45	32,91	86
,90	4,27	86,58	8,53	86,06	12,76	85,33	16,97	84,39	21,14	83,25	25,21	81,91	29,31	80,38	33,29	87
,89	4,32	87,58	8,63	87,05	12,91	86,31	17,17	85,36	21,38	84,21	25,54	82,86	29,65	81,30	33,67	88
,89	4,37	88,57	8,72	88,04	13,06	87,29	17,36	86,33	21,62	85,17	2 ,83	83,80	29,98	82,23	34,06	89
,89	4,42	89,57	8,82	89,02	13,21	88,27	17,56	87,30	21,87	86,12	26,12	84,74	30,32	83,15	34,44	90
,89	4,47	90,56	8,92	90,01	13,3	89,25	17,75	88,27	22,11	87,08	26,41	85,68	30,66	84,07	34,82	91
,89	4,52	91,56	9,02	91,00	13,50	90,23	17,95	89,24	22,35	88,04	26,70	86,62	30,99	85,00	35,21	92
,89	4,56	92,55	9,12	91,99	13,65	91,21	18,14	90,21	22,60	89,00	27,00	87,56	31,33	85,92	35,59	93
,89	4,61	93,55	9,21	92,98	13,79	92,19	18,34	91,18	22,84	89,95	27,29	88,51	31,67	86,85	35,97	94
,89	4,66	94,54	9,31	93,97	13,94	93,18	18,54	92,15	23,08	90,91	27,58	89,45	32,00	87,77	36,35	95
,88	4,71	95,54	9,41	94,96	14,09	94,16	18,73	93,12	23,33	91,87	27,87	90,39	32,34	88,69	36,74	96
,88	4,76	96,53	9,51	95,95	14,2	95,14	18,92	94,09	23,57	92,82	28,16	91,33	32,68	89,62	37,12	97
,88	4,81	97,53	9,61	96,94	14,38	96,12	19,12	95,06	23,81	93,78	28,45	92,27	33,01	90,54	37,50	98
,88	4,86	98,52	9,70	97,93	14,53	97,10	19,31	96,03	24,05	94,74	28,74	93,21	33,35	91,46	37,88	99
,88	4,91	99,52	9,80	98,92	4,67	98,08	19,51	97,00	24,30	95,69	29,03	94,15	33,69	92,39	38,27	100
,9	4,96	100,5	9,90	99,91	14,82	99,06	19,70	97,97	24,54	96,65	29,32	95,10	34,03	93,31	38,65	101
,9	5,01	101,5	10,00	100,9	14,97	100,0	19,90	98,94	24,78	97,61	9,61	96,04	34,36	94,24	39,03	102
,9	5,05	102,5	10,10	101,9	15,11	101,0	20,09	99,91	25,03	98,56	29,90	96,98	34,70	95,16	39,42	103
,9	5,10	103,5	10,19	102,9	15,26	102,0	20,29	100,9	25,27	99,52	30,19	97,92	35,04	96,08	39,80	104
,9	5,15	104,5	10,29	103,9	15,41	103,0	20,48	101,9	25,51	100,5	30,48	98,86	35,37	97,01	40,18	105
,9	5,20	105,5	10,39	104,9	15,55	104,0	20,68	102,8	25,76	101,4	30,77	99,80	35,71	97,93	40,56	106
,9	5,25	106,5	10,49	105,8	15,70	104,9	20,88	03,8	26,00	102,4	31,06	100,7	36,05	98,86	40,95	107
,9	5,30	107,5	10,59	106,8	15,85	105,9	21,07	104,8	26,24	103,4	31,35	101,7	36,38	99,78	41,33	108
,9	5,35	108,5	10,68	107,8	15,99	106,9	21,26	105,7	26,48	104,3	31,64	102,6	36,72	100,7	41,71	109
,9	5,40	109,5	10,78	108,8	16,14	107,9	21,46	106,7	26,73	105,3	31,93	103,6	37,06	101,6	42,09	110
,9	5,45	110,5	10,88	109,8	16,29	108,9	21,66	107,7	26,97	106,2	32,22	104,5	37,39	102,6	42,48	111
,9	5,50	111,5	10,98	110,8	16,43	109,8	21,85	108,6	27,21	107,2	32,51	105,5	37,73	103,5	42,86	112
,9	5,55	112,5	11,08	111,8	16,58	110,8	22,05	109,6	27,46	108,1	32,80	106,4	38,07	104,4	43,24	113
,9	5,59	113,5	11,17	112,8	16,73	111,8	22,24	110,6	27,70	109,1	33,09	107,3	38,41	105,3	43,63	114
,9	5,64	114,4	11,27	113,8	16,87	112,8	22,44	111,6	27,94	110,0	33,38	108,3	38,74	106,2	44,01	115
,9	5,69	115,4	11,37	14.7	17,02	113,8	22,63	112,5	28,19	111,0	33,67	109,2	39,08	107,2	44,39	116
,9	5,74	116,4	11,47	115,7	17,17	114,8	22,83	113,5	28,43	112,0	33,96	110,2	39,42	108,1	44,77	117
,9	5,79	117,4	11,57	116,7	17,31	115,7	23,02	114,5	28,67	112,9	34,25	111,1	39,75	109,0	45, 6	118
,9	5,84	118,4	11,66	117,7	17,46	116,7	23,22	115,4	28,91	113,9	34,54	112,0	40,09	109,9	45,54	119
,9	5,89	119,4	11,76	118,7	17.61	117,7	23,41	116,4	29,16	114,8	4,83	113,0	40,43	110,9	45,92	120
p.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	Lat.	Diſtance
		½		¼		0		¾		½		¼		0		
7 Points								6 Points								

Distance	2 Points						3 Points								4 Points	
	$\frac{1}{4}$		$\frac{1}{2}$		$\frac{3}{4}$		0		$\frac{1}{4}$		$\frac{1}{2}$		$\frac{3}{4}$		0	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	De
1	0,90	0,43	0,88	0,47	0,86	0,51	0,83	0,56	0,80	0,60	0,77	0,63	0,74	0,67	0,71	0,
2	1,81	0,85	1,76	0,94	1,71	1,03	1,66	1,11	1,61	1,19	1,55	1,27	1,48	1,34	1,41	1,
3	2,71	1,28	2,65	1,41	2,57	1,54	2,49	1,67	2,41	1,79	2,32	1,90	2,22	2,01	2,12	2,
4	3,62	1,71	3,53	1,89	3,43	2,06	3,33	2,22	3,21	2,38	3,09	2,54	2,96	2,69	2,83	2,
5	4,52	2,14	4,41	2,36	4,29	2,57	4,16	2,78	4,02	2,98	3,86	3,17	3,70	3,36	3,53	3,
6	5,42	2,56	5,29	2,83	5,15	3,08	4,99	3,33	4,82	3,57	4,64	3,81	4,45	4,03	4,24	4,
7	6,33	2,99	6,17	3,30	6,00	3,60	5,82	3,89	5,62	4,17	5,41	4,44	5,19	4,70	4,95	4,
8	7,23	3,42	7,05	3,77	6,86	4,11	6,65	4,44	6,43	4,77	6,18	5,07	5,93	5,37	5,66	5,
9	8,14	3,85	7,94	4,24	7,72	4,63	7,48	5,00	7,23	5,36	6,96	5,71	6,67	6,04	6,36	6,
10	9,04	4,28	8,82	4,71	8,58	5,14	8,32	5,56	8,03	5,96	7,73	6,34	7,41	6,72	7,07	7,
11	9,94	4,70	9,70	5,18	9,43	5,65	9,15	6,11	8,83	6,55	8,50	6,98	8,15	7,39	7,78	7,
12	10,8	5,13	10,58	5,66	10,29	6,17	9,98	6,67	9,64	7,15	9,28	7,61	8,89	8,06	8,49	8,
13	11,75	5,56	1,46	6,13	11,15	6,68	10,81	7,22	10,44	7,74	10,05	8,25	9,63	8,73	9,19	9,
14	12,66	5,99	12,35	6,60	12,01	7,20	11,64	7,78	11,24	8,33	10,82	8,88	10,37	9,40	9,90	9,
15	13,56	6,41	13,23	7,07	12,87	7,71	12,47	8,33	12,05	8,93	11,59	9,51	11,11	10,07	10,61	10,
16	14,46	6,84	14,11	7,54	13,72	8,22	13,30	8,89	12,85	9,52	12,37	10,15	11,8	10,75	11,31	11,
17	15,37	7,27	14,99	8,01	14,58	8,74	14,13	9,45	13,65	10,12	13,14	10,78	12,60	11,42	12,02	12,
18	16,27	7,70	15,87	8,48	15,44	9,25	14,96	10,00	14,46	10,71	13,91	11,42	13,34	12,09	12,73	12,
19	17,18	8,13	16,76	8,95	16,30	9,77	15,80	10,56	15,26	11,31	14,69	12,05	14,08	12,76	13,43	13,
20	18,08	8,55	17,64	9,43	17,15	10,28	16,63	11,12	16,06	11,91	15,46	12,69	14,82	13,43	14,14	14,
21	18,98	8,98	18,52	9,90	18,01	10,80	17,46	11,67	16,87	12,51	16,23	13,32	15,56	14,10	14,85	14,
22	19,89	9,41	19,4	10,37	18,87	11,31	18,29	12,22	17,67	13,11	17,01	13,95	16,30	14,77	15,56	15,
23	20,79	9,83	20,28	10,84	19,73	11,82	19,12	12,78	18,47	13,70	17,78	14,59	17,04	15,45	16,26	16,
24	21,69	10,26	21,17	11,31	20,59	12,34	19,95	13,34	19,28	14,30	18,55	15,22	17,78	16,12	16,97	16,
25	22,60	10,69	22,05	11,78	21,44	12,85	20,78	13,89	20,08	14,89	19,33	15,86	18,52	16,79	17,68	17,
26	23,50	11,12	22,93	12,25	22,30	13,37	21,62	14,45	20,88	15,49	20,10	16,49	19,26	17,46	18,38	18,
27	24,41	11,54	23,81	12,72	23,16	13,88	22,45	15,00	21,68	16,09	20,87	17,12	20,01	18,13	19,09	19,
28	25,31	11,97	24,69	13,2	24,02	14,39	23,28	15,56	22,49	16,68	21,64	17,76	20,75	18,81	19,80	19,
29	26,21	12,40	25,58	13,67	24,88	14,91	24,11	16,12	23,29	17,28	22,42	18,39	21,49	19,48	20,51	20,
30	27,12	12,83	26,46	14,14	25,73	15,42	24,94	16,67	24,10	17,87	23,19	19,03	22,23	20,15	21,21	21,
31	28,02	13,25	27,34	14,61	26,59	15,94	25,78	17,22	24,90	18,46	23,96	19,67	22,97	20,82	21,92	21,
32	28,93	13,68	28,23	15,09	27,45	16,45	26,61	17,78	25,70	19,06	24,74	20,30	23,71	21,49	22,63	22,
33	29,83	14,11	29,11	15,56	28,31	16,96	27,44	18,34	26,51	19,66	25,51	20,93	24,45	22,16	23,33	23,
34	30,73	14,54	29,99	16,03	29,16	17,48	28,27	18,89	27,31	20,25	26,28	21,57	25,19	22,83	24,04	24,
35	31,64	14,97	30,87	16,51	30,02	17,99	29,10	19,45	28,11	20,85	27,05	22,21	25,93	23,51	24,75	24,
36	32,54	15,39	31,76	16,98	30,88	18,51	29,93	20,00	28,91	21,45	27,83	22,84	26,67	24,18	25,46	25,
37	33,45	15,82	32,64	17,45	31,74	19,02	30,76	20,56	29,72	22,04	28,60	23,47	27,42	24,85	26,16	26,
38	34,35	16,25	33,52	17,92	32,60	19,53	31,59	21,12	30,52	22,64	29,37	24,10	28,16	25,52	26,87	26,
39	35,26	16,68	34,40	18,39	33,45	20,05	32,42	21,67	31,32	23,23	30,15	24,74	28,90	26,19	27,58	27,
40	36,16	17,10	35,28	18,86	34,31	20,56	33,26	22,22	32,13	23,83	30,92	25,38	29,64	26,86	28,28	28,
41	37,06	17,53	36,16	19,33	35,17	21,08	34,09	22,78	32,93	24,42	31,69	26,01	30,38	27,53	28,99	28,
42	37,97	17,96	37,04	19,80	36,03	21,59	34,92	23,34	33,73	25,02	32,47	26,64	31,12	28,21	29,70	29,
43	38,87	18,39	37,92	20,27	36,88	22,10	35,75	23,89	34,54	25,62	33,24	27,28	31,86	28,88	30,41	30,
44	39,77	18,81	38,80	20,74	37,74	22,62	36,58	24,45	35,34	26,21	34,01	27,91	32,60	29,55	31,11	31,
45	40,68	19,24	39,69	21,21	38,60	23,13	37,41	25,00	36,14	26,82	34,78	28,55	33,34	30,22	31,82	31,
46	41,58	19,67	40,57	21,68	39,46	23,65	38,24	25,56	36,95	27,41	35,56	29,18	34,08	30,89	32,53	32,
47	42,49	20,10	41,45	22,15	40,32	24,16	39,08	26,12	37,75	28,01	36,33	29,81	34,82	31,57	33,23	33,
48	43,39	20,53	42,33	22,62	41,17	24,68	39,91	26,67	38,55	28,61	37,10	30,45	35,57	32,24	33,94	33,
49	44,29	20,95	43,21	23,09	42,03	25,19	40,74	27,23	39,36	29,20	37,88	31,08	36,31	32,91	34,65	34,
50	45,20	21,38	44,10	23,57	42,89	25,70	41,57	27,78	40,16	29,79	38,65	31,72	37,05	33,58	35,35	35,
51	46,10	21,81	44,98	24,04	43,74	26,22	42,40	28,34	40,96	30,38	39,42	32,3	37,79	34,25	36,06	36,
52	47,01	22,23	45,86	24,51	44,60	26,73	43,23	28,89	41,77	30,98	40,20	32,99	38,53	34,92	36,77	36,
53	47,91	22,66	46,74	24,98	45,46	27,25	44,07	29,45	42,57	31,57	40,97	33,62	39,27	35,59	37,47	37,
54	48,81	23,09	47,62	25,45	46,32	27,76	44,90	30,00	43,37	32,17	41,74	34,26	40,01	36,27	38,18	38,
55	49,72	23,52	48,51	25,92	47,18	28,27	45,73	30,56	44,18	32,76	42,52	34,89	40,75	36,94	38,89	38,
56	50,62	23,95	49,39	26,40	48,03	28,79	46,56	31,12	44,98	33,36	43,29	35,52	41,49	37,61	39,60	39,
57	51,53	24,37	50,27	26,87	48,89	29,30	47,39	31,67	45,78	33,96	44,06	36,16	42,23	38,28	40,30	40,
58	52,43	24,80	51,15	27,34	49,75	29,82	48,22	32,23	46,58	34,55	44,83	36,79	42,98	38,95	41,01	41,
59	53,33	25,22	52,03	27,81	50,61	30,33	49,05	32,78	47,39	35,15	45,61	37,43	43,72	39,63	41,72	41,
60	54,24	25,65	52,92	28,28	51,46	30,85	49,89	33,33	48,19	35,74	46,38	38,06	44,46	40,29	42,43	42,
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	La
	$\frac{3}{4}$		$\frac{1}{2}$		$\frac{1}{4}$		0		$\frac{3}{4}$		$\frac{1}{2}$		$\frac{1}{4}$		0	
	5 Points								4 Points							

2 Points					3 Points								4 Points		Distance
	½		¾		0		¼		½		¾		0		
Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
26,08	53,80	28,75	52,32	31,36	50,72	33,89	49,00	36,34	47,15	38,70	45,20	40,97	43,13	43,13	61
26,51	54,68	29,22	53,18	31,87	51,55	34,45	49,80	36,93	47,93	39,33	45,94	41,64	43,84	43,84	62
26,94	55,56	29,70	54,04	32,39	52,38	35,00	50,60	37,53	48,70	39,96	46,68	42,31	44,55	44,55	63
27,36	56,44	30,17	54,90	32,90	53,21	35,56	51,40	38,13	49,47	40,60	47,42	42,98	45,25	45,25	64
27,79	57,33	30,64	55,75	33,42	54,04	36,11	52,21	38,72	50,25	41,24	48,16	43,65	45,96	45,96	65
28,22	58,21	31,11	56,61	33,93	54,87	36,67	53,01	39,32	51,02	41,87	48,90	44,33	46,67	46,67	66
28,65	59,09	31,58	57,47	34,44	55,71	37,23	53,81	39,91	51,79	42,50	49,64	44,99	47,38	47,38	67
29,07	59,97	32,05	58,33	34,96	56,54	37,78	54,62	40,51	52,56	43,13	50,38	45,67	48,08	48,08	68
29,51	60,85	32,52	59,19	35,47	57,37	38,34	55,42	41,11	53,34	43,77	51,13	46,34	48,79	48,79	69
29,93	61,73	33,00	60,04	35,99	58,20	38,89	56,22	41,70	54,11	44,41	51,87	47,01	49,50	49,50	70
30,36	62,62	33,47	60,90	36,50	59,03	39,45	57,03	42,29	54,88	45,04	52,61	47,68	50,20	50,20	71
30,78	63,50	33,94	61,76	37,01	59,87	40,00	57,83	42,89	55,66	45,67	53,35	48,35	50,91	50,91	72
31,21	64,38	34,41	62,62	37,53	60,70	40,56	58,63	43,49	56,43	46,31	54,09	49,02	51,62	51,62	73
31,64	65,26	34,88	63,47	38,04	61,53	41,11	59,44	44,08	57,20	46,94	54,83	49,70	52,33	52,33	74
32,07	66,14	35,35	64,33	38,56	62,38	41,67	60,24	44,68	57,98	47,58	55,57	50,37	53,03	53,0	75
32,50	67,03	35,82	65,19	39,07	63,2	42,22	61,04	45,27	58,75	48,21	56,31	51,04	53,74	53,74	76
32,92	67,91	36,29	66,05	39,58	64,04	42,78	61,85	45,87	59,52	48,84	57,05	51,71	54,45	54,45	77
33,35	68,79	36,76	66,91	40,10	64,87	43,34	62,65	46,47	50,29	49,48	57,79	52,38	55,15	55,15	78
33,78	69,67	37,24	67,76	40,61	65,70	43,89	63,4	47,06	61,07	50,11	58,54	53,06	55,86	55,86	79
34,20	70,55	37,71	68,62	41,13	66,52	44,45	64,26	47,66	61,84	50,75	59,28	53,72	56,57	56,57	80
34,63	71,44	38,18	69,48	41,64	67,35	45,00	65,06	48,25	62,51	51,38	60,02	54,40	57,28	57,28	81
35,06	72,32	38,65	70,33	42,16	68,18	45,56	65,86	48,85	63,39	52,02	60,76	55,07	57,98	57,98	82
35,49	73,20	39,12	71,19	42,67	69,01	46,11	66,67	49,44	64,16	52,65	61,50	55,74	58,69	58,69	83
35,92	73,08	39,59	72,05	43,18	69,84	46,67	67,47	50,04	64,93	53,29	62,24	56,41	59,40	59,4	84
36,34	74,96	40,07	72,91	43,70	70,67	47,23	68,27	50,64	65,71	53,92	62,98	57,08	60,10	60,10	85
36,77	75,85	40,54	73,77	44,21	71,50	47,78	69,08	51,24	66,48	54,55	63,72	57,76	60,81	60,81	86
37,20	76,73	41,01	74,62	44,73	72,34	48,34	69,88	51,83	67,25	55,19	64,46	58,43	61,52	61,52	87
37,63	77,61	41,48	75,48	45,24	73,17	48,89	70,68	52,42	68,02	55,83	65,20	59,10	62,22	62,22	88
38,06	78,49	41,95	76,34	45,75	74,00	49,45	71,48	53,02	68,80	56,46	65,94	59,77	62,93	62,93	89
38,49	79,37	42,42	77,20	46,27	74,83	50,00	72,29	53,61	69,57	57,09	66,69	60,44	63,64	63,64	90
38,92	80,26	42,90	78,05	46,78	75,66	50,56	73,09	54,21	70,34	57,73	67,43	61,11	64,35	64,35	91
39,35	81,14	43,37	78,91	47,30	76,49	51,11	73,90	54,80	71,12	58,36	68,17	61,78	65,05	65,05	92
39,78	82,02	43,84	79,77	47,81	77,33	51,67	74,70	55,40	71,89	59,00	68,91	62,46	65,76	65,76	93
40,20	82,90	44,31	80,63	48,32	78,16	52,22	75,50	56,00	72,66	59,63	69,65	63,13	66,47	66,47	94
40,63	83,78	44,78	81,49	48,84	79,00	52,78	76,30	56,59	73,44	60,27	70,39	63,80	67,1	67,18	95
41,06	84,67	45,25	82,34	49,35	79,83	53,34	77,11	57,19	74,21	60,90	71,13	64,47	67,88	67,88	96
41,49	85,55	45,72	83,20	49,87	80,66	53,89	77,91	57,78	74,98	61,53	71,87	65,14	68,59	68,59	97
41,91	86,43	46,19	84,06	50,38	81,49	54,45	78,71	58,38	75,75	62,17	72,6	65,81	69,30	69,30	98
42,34	87,31	46,66	84,92	50,89	82,32	55,00	79,52	58,98	76,53	62,80	73,35	66,49	70,00	70,00	99
42,76	88,19	47,14	85,77	51,41	83,15	55,56	80,32	59,57	77,30	63,44	74,00	67,16	70,71	70,71	100
43,18	89,07	47,61	86,63	51,92	83,98	56,11	81,12	60,17	78,07	64,07	74,84	67,83	71,42	71,42	101
43,61	89,96	48,08	87,49	52,44	84,81	56,67	81,93	60,76	78,85	64,71	75,58	68,50	72,13	72,13	102
44,04	90,84	48,55	88,15	52,95	85,64	57,22	82,73	61,36	79,62	65,34	76,32	69,17	72,83	72,83	103
44,47	91,72	49,02	89,21	53,47	86,47	57,78	83,53	61,95	80,39	65,97	77,06	69,84	73,54	73,54	104
44,90	92,60	49,49	90,05	53,98	87,31	58,34	84,34	62,55	81,17	66,61	77,80	70,52	74,25	74,25	105
45,33	93,48	49,96	90,92	54,49	88,14	58,89	85,14	63,15	81,94	67,24	78,54	71,19	74,95	74,95	106
45,75	94,37	50,44	91,78	55,01	88,79	59,45	85,94	63,74	82,71	67,88	79,28	71,86	75,66	75,66	107
46,18	95,25	50,91	92,64	55,52	89,80	60,00	86,75	64,34	83,48	68,51	80,02	72,53	76,37	76,37	108
46,51	96,13	51,38	93,50	56,04	90,63	60,56	87,55	64,93	84,26	69,15	80,76	73,20	77,07	77,07	109
47,03	97,01	51,85	94,35	56,55	91,46	61,11	88,35	65,53	85,03	69,78	81,50	73,87	77,78	77,78	110
47,46	97,89	52,32	95,21	57,06	92,29	61,67	89,16	66,12	85,80	70,42	82,25	74,54	78,49	78,49	111
47,89	98,78	52,79	96,07	57,58	93,12	62,22	89,96	66,72	86,58	71,05	82,99	75,22	79,20	79,20	112
48,31	99,66	53,27	96,92	58,09	93,96	62,78	90,76	67,31	87,35	71,68	83,73	75,89	79,90	79,90	113
48,74	100,5	53,74	97,78	58,61	94,79	63,34	91,57	67,91	88,12	72,32	84,47	76,56	80,61	80,61	114
49,17	101,4	54,21	98,64	59,12	95,62	63,89	92,37	68,51	88,90	72,95	85,21	77,23	81,32	81,32	115
49,60	102,3	54,68	99,50	59,63	96,45	64,45	93,17	69,10	89,67	73,58	85,95	77,90	82,02	82,02	116
50,03	103,2	55,15	100,4	60,15	97,28	64,99	93,97	69,70	90,44	74,22	86,69	78,58	82,73	82,73	117
50,45	104,1	55,62	101,2	60,66	98,11	65,56	94,78	70,29	91,21	74,85	87,43	79,25	83,44	83,44	118
50,88	105,0	56,09	102,1	61,18	98,94	66,11	95,58	70,89	91,99	75,49	88,17	79,92	84,14	84,14	119
51,31	105,8	56,57	102,9	61,69	99,78	66,67	96,39	71,48	92,76	76,13	88,91	80,59	84,85	84,85	120
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	½		¼		0		¾		½		¼		0		
5 Points								4 Points							

Distance	0 Degrees						1 Degree							
	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.
1	1,00	0,00	1,00	0,01	1,00	0,01	1,00	0,02	1,00	0,02	1,00	0,03	1,00	0,03
2	2,00	0,01	2,00	0,02	2,00	0,03	2,00	0,04	2,00	0,04	2,00	0,05	2,00	0,06
3	3,00	0,01	3,00	0,03	3,00	0,04	3,00	0,05	3,00	0,07	3,00	0,08	3,00	0,09
4	4,00	0,02	4,00	0,03	4,00	0,05	4,00	0,07	4,00	0,09	4,00	0,10	4,00	0,12
5	5,00	0,02	5,00	0,04	5,00	0,07	5,00	0,09	5,00	0,11	5,00	0,13	5,00	0,15
6	6,00	0,03	6,00	0,05	6,00	0,08	6,00	0,11	6,00	0,13	6,00	0,16	6,00	0,18
7	7,00	0,03	7,00	0,06	7,00	0,09	7,00	0,12	7,00	0,15	7,00	0,18	7,00	0,21
8	8,00	0,04	8,00	0,07	8,00	0,10	8,00	0,14	8,00	0,18	8,00	0,21	8,00	0,25
9	9,00	0,04	9,00	0,08	9,00	0,12	9,00	0,16	9,00	0,20	9,00	0,24	9,00	0,28
10	10,00	0,04	10,00	0,09	10,00	0,13	10,00	0,18	10,00	0,22	10,00	0,26	10,00	0,31
11	11,00	0,05	11,00	0,10	11,00	0,14	11,00	0,19	11,00	0,24	11,00	0,28	11,00	0,34
12	12,00	0,05	12,00	0,10	12,00	0,16	12,00	0,21	12,00	0,26	12,00	0,31	11,99	0,37
13	13,00	0,06	13,00	0,11	13,00	0,17	13,00	0,23	13,00	0,28	13,00	0,34	12,99	0,40
14	14,00	0,06	14,00	0,12	14,00	0,18	14,00	0,25	14,00	0,31	14,00	0,37	13,99	0,43
15	15,00	0,07	15,00	0,13	15,00	0,20	15,00	0,26	15,00	0,33	15,00	0,39	14,99	0,46
16	16,00	0,07	16,00	0,14	16,00	0,21	16,00	0,28	16,00	0,35	16,00	0,42	15,99	0,49
17	17,00	0,07	17,00	0,15	17,00	0,22	17,00	0,30	17,00	0,37	17,00	0,45	16,99	0,52
18	18,00	0,08	18,00	0,16	18,00	0,24	18,00	0,32	18,00	0,39	17,99	0,47	17,99	0,55
19	19,00	0,08	19,00	0,17	19,00	0,25	19,00	0,33	19,00	0,42	18,99	0,50	18,99	0,58
20	20,00	0,09	20,00	0,17	20,00	0,26	20,00	0,35	20,00	0,44	19,99	0,52	19,99	0,61
21	21,00	0,09	21,00	0,18	21,00	0,28	21,00	0,37	21,00	0,46	20,99	0,55	20,99	0,64
22	22,00	0,10	22,00	0,19	22,00	0,29	22,00	0,38	22,00	0,48	21,99	0,58	21,99	0,67
23	23,00	0,10	23,00	0,20	23,00	0,30	23,00	0,40	23,00	0,50	22,99	0,60	22,99	0,70
24	24,00	0,10	24,00	0,21	24,00	0,31	24,06	0,42	24,00	0,52	23,99	0,63	23,99	0,7
25	25,00	0,11	25,00	0,22	25,00	0,33	25,06	0,44	24,99	0,55	24,99	0,65	24,99	0,76
26	26,00	0,11	26,00	0,23	26,00	0,34	26,00	0,45	25,99	0,57	25,99	0,68	25,99	0,7
27	27,00	0,12	27,00	0,24	27,00	0,35	27,00	0,47	26,99	0,59	26,99	0,71	26,99	0,8
28	28,00	0,12	28,00	0,24	28,00	0,37	28,00	0,49	27,99	0,61	27,99	0,73	27,99	0,86
29	29,00	0,13	29,00	0,25	29,00	0,38	29,00	0,51	28,99	0,63	28,99	0,76	28,99	0,8
30	30,00	0,13	30,00	0,26	30,00	0,39	30,00	0,52	29,99	0,65	29,99	0,79	29,99	0,9
31	31,00	0,14	31,00	0,27	31,00	0,41	31,00	0,54	30,99	0,68	30,99	0,81	30,99	0,9
32	32,00	0,14	32,00	0,28	32,00	0,42	32,00	0,56	31,99	0,70	31,99	0,84	31,99	0,9
33	33,00	0,14	33,00	0,29	33,00	0,43	33,00	0,58	32,99	0,72	32,99	0,86	32,99	1,0
34	34,00	0,15	34,00	0,30	34,00	0,44	33,99	0,59	33,99	0,74	33,99	0,89	33,99	1,0
35	35,00	0,15	35,00	0,31	35,00	0,46	34,99	0,61	34,99	0,76	34,99	0,92	34,99	1,0
36	36,00	0,16	36,00	0,31	36,00	0,47	35,99	0,63	35,99	0,79	35,99	0,94	35,99	1,1
37	37,00	0,16	37,00	0,32	37,00	0,48	36,99	0,65	36,99	0,81	36,99	0,97	36,98	1,1
38	38,00	0,17	38,00	0,33	38,00	0,50	37,99	0,66	37,99	0,83	37,99	0,99	37,98	1,1
39	39,00	0,17	39,00	0,34	39,00	0,51	38,99	0,68	38,99	0,85	38,99	1,02	38,98	1,1
40	40,00	0,17	40,00	0,35	40,00	0,52	39,99	0,70	39,99	0,87	39,99	1,05	39,98	1,2
41	41,00	0,18	41,00	0,36	41,00	0,54	40,99	0,72	40,99	0,89	40,99	1,07	40,98	1,2
42	42,00	0,18	42,00	0,37	42,00	0,55	41,99	0,73	41,99	0,92	41,99	1,10	41,98	1,2
43	43,00	0,19	43,00	0,38	43,00	0,56	42,99	0,75	42,99	0,94	42,99	1,13	42,98	1,3
44	44,00	0,19	44,00	0,38	44,00	0,58	43,99	0,77	43,99	0,96	43,99	1,15	43,98	1,3
45	45,00	0,20	45,00	0,39	45,00	0,59	44,99	0,79	44,99	0,98	44,99	1,18	44,98	1,3
46	46,00	0,20	46,00	0,40	46,00	0,60	45,99	0,80	45,99	1,00	45,99	1,20	45,98	1,4
47	47,00	0,21	47,00	0,41	47,00	0,61	46,99	0,82	46,99	1,03	46,99	1,23	46,98	1,4
48	48,00	0,21	48,00	0,42	48,00	0,63	47,99	0,84	47,99	1,05	47,98	1,26	47,98	1,4
49	49,00	0,21	49,00	0,43	49,00	0,64	48,99	0,86	48,99	1,07	48,98	1,28	48,98	1,5
50	50,00	0,22	50,00	0,44	50,00	0,65	49,99	0,87	49,99	1,09	49,98	1,31	49,98	1,5
51	51,00	0,22	51,00	0,45	50,99	0,67	50,99	0,89	50,99	1,11	50,98	1,34	50,98	1,5
52	52,00	0,23	52,00	0,45	51,99	0,68	51,99	0,91	51,99	1,14	51,98	1,36	51,98	1,5
53	53,00	0,23	53,00	0,46	52,99	0,69	52,99	0,93	52,99	1,16	52,98	1,39	52,98	1,6
54	54,00	0,24	54,00	0,47	53,99	0,71	53,99	0,94	53,99	1,18	53,98	1,41	53,98	1,6
55	55,00	0,24	55,00	0,48	54,99	0,72	54,99	0,96	54,99	1,20	54,98	1,44	54,98	1,6
56	56,00	0,24	56,00	0,49	55,99	0,73	55,99	0,98	55,99	1,22	55,98	1,47	55,98	1,7
57	57,00	0,25	57,00	0,50	56,99	0,75	56,99	1,00	56,99	1,24	56,98	1,49	56,97	1,7
58	58,00	0,25	58,00	0,51	57,99	0,76	57,99	1,01	57,99	1,27	57,98	1,52	57,97	1,7
59	59,00	0,26	59,00	0,51	58,99	0,77	58,99	1,03	58,99	1,29	58,98	1,54	58,97	1,8
60	60,00	0,26	60,00	0,52	59,99	0,79	59,99	1,05	59,99	1,31	59,98	1,57	59,97	1,8
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat
	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.	
	89 Degrees								88 Degrees					

0 Degrees						1 Degree								Diſtance
15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61,00	0,27	61,00	0,53	60,99	0,80	60,99	1,06	60,98	1,33	60,98	1,60	60,97	1,86	61
62,00	0,27	62,00	0,54	61,99	0,81	61,99	1,08	61,98	1,35	61,98	1,62	61,97	1,89	62
63,00	0,28	63,00	0,55	62,99	0,82	62,99	1,10	62,98	1,38	62,98	1,65	62,97	1,92	63
64,00	0,28	64,00	0,56	63,99	0,84	63,99	1,12	63,98	1,40	63,98	1,67	63,97	1,95	64
65,00	0,28	65,00	0,57	64,99	0,85	64,99	1,13	64,98	1,42	64,98	1,70	64,97	1,99	65
66,00	0,29	66,00	0,58	65,99	0,86	65,99	1,15	65,98	1,44	65,98	1,73	65,97	2,02	66
67,00	0,29	67,00	0,58	66,99	0,88	66,99	1,17	66,98	1,46	66,98	1,75	66,97	2,05	67
68,00	0,30	68,00	0,59	67,99	0,89	67,99	1,19	67,98	1,48	67,98	1,78	67,97	2,08	68
69,00	0,30	69,00	0,60	68,99	0,90	68,99	1,20	68,98	1,51	68,98	1,81	68,97	2,11	69
70,00	0,31	70,00	0,61	69,99	0,92	69,99	1,22	69,98	1,53	69,98	1,83	69,97	2,14	70
71,00	0,31	71,00	0,62	70,99	0,93	70,99	1,24	70,98	1,55	70,98	1,86	70,97	2,17	71
72,00	0,31	72,00	0,63	71,99	0,94	71,99	1,26	71,98	1,57	71,98	1,88	71,97	2,20	72
73,00	0,32	73,00	0,64	72,99	0,96	72,99	1,27	72,98	1,59	72,98	1,91	72,97	2,23	73
74,00	0,32	74,00	0,65	73,99	0,97	73,99	1,29	73,98	1,62	73,98	1,94	73,97	2,26	74
75,00	0,33	75,00	0,65	74,99	0,98	74,99	1,31	74,98	1,64	74,98	1,96	74,97	2,29	75
76,00	0,33	76,00	0,66	75,99	0,99	75,99	1,33	75,98	1,66	75,97	1,99	75,97	2,32	76
77,00	0,34	77,00	0,67	76,99	1,01	76,99	1,34	76,98	1,68	76,97	2,02	76,97	2,35	77
78,00	0,34	78,00	0,68	77,99	1,02	77,99	1,36	77,98	1,70	77,97	2,04	77,96	2,38	78
79,00	0,35	79,00	0,69	78,99	1,03	78,99	1,38	78,98	1,72	78,97	2,07	78,95	2,41	79
80,00	0,35	80,00	0,70	79,99	1,05	79,99	1,40	79,98	1,75	79,97	2,09	79,96	2,44	80
81,00	0,35	81,00	0,71	80,99	1,06	80,99	1,41	80,98	1,77	80,97	2,12	80,96	2,47	81
82,00	0,36	82,00	0,72	81,99	1,07	81,99	1,43	81,98	1,79	81,97	2,15	81,96	2,50	82
83,00	0,36	83,00	0,72	82,99	1,09	82,99	1,45	82,98	1,81	82,97	2,17	82,96	2,54	83
84,00	0,37	84,00	0,73	83,99	1,10	83,99	1,47	83,98	1,83	83,97	2,20	83,96	2,57	84
85,00	0,37	85,00	0,74	84,99	1,11	84,99	1,48	84,98	1,85	84,97	2,23	84,96	2,60	85
86,00	0,38	86,00	0,75	85,99	1,13	85,99	1,50	85,98	1,88	85,97	2,25	85,96	2,63	86
87,00	0,38	87,00	0,76	86,99	1,14	86,99	1,52	86,98	1,90	86,97	2,28	86,96	2,66	87
88,00	0,38	88,00	0,77	87,99	1,15	87,99	1,54	87,98	1,92	87,97	2,30	87,96	2,69	88
89,00	0,39	89,00	0,78	88,99	1,16	88,99	1,55	88,98	1,94	88,97	2,33	88,96	2,72	89
90,00	0,39	90,00	0,79	89,99	1,18	89,99	1,57	89,98	1,96	89,97	2,36	89,96	2,75	90
91,00	0,40	91,00	0,79	90,99	1,19	90,99	1,59	90,98	1,99	90,97	2,38	90,96	2,78	91
92,00	0,40	92,00	0,80	91,99	1,20	91,99	1,61	91,98	2,01	91,97	2,41	91,96	2,81	92
93,00	0,41	93,00	0,81	92,99	1,22	92,99	1,62	92,98	2,03	92,97	2,43	92,96	2,84	93
94,00	0,41	94,00	0,82	93,99	1,23	93,99	1,64	93,98	2,05	93,97	2,46	93,96	2,87	94
95,00	0,41	95,00	0,83	94,99	1,24	94,99	1,66	94,98	2,07	94,97	2,49	94,96	2,90	95
96,00	0,42	96,00	0,84	95,99	1,26	95,99	1,68	95,98	2,09	95,97	2,51	95,96	2,94	96
97,00	0,42	97,00	0,85	96,99	1,27	96,99	1,69	96,98	2,12	96,97	2,54	96,96	2,96	97
98,00	0,43	98,00	0,86	97,99	1,28	97,99	1,71	97,98	2,14	97,97	2,57	97,96	2,99	98
99,00	0,43	99,00	0,86	98,99	1,30	98,99	1,73	98,98	2,16	98,97	2,59	98,95	3,02	99
100,0	0,44	100,0	0,87	99,99	1,31	99,99	1,75	99,98	2,18	99,97	2,62	99,95	3,05	100
101,0	0,44	101,0	0,88	101,0	1,32	101,0	1,76	101,0	2,20	101,0	2,64	101,0	3,09	101
102,0	0,4	102,0	0,89	102,0	1,34	102,0	1,78	102,0	2,23	102,0	2,67	102,0	3,12	102
103,0	0,4	103,0	0,90	103,0	1,35	103,0	1,80	103,0	2,25	103,0	2,70	103,0	3,15	103
104,0	0,45	104,0	0,91	104,0	1,36	104,0	1,82	104,0	2,27	104,0	2,72	104,0	3,18	104
105,0	0,46	105,0	0,92	105,0	1,37	105,0	1,83	105,0	2,29	105,0	2,75	105,0	3,21	105
106,0	0,46	106,0	0,92	106,0	1,39	106,0	1,85	106,0	2,31	106,0	2,78	106,0	3,24	106
107,0	0,47	107,0	0,93	107,0	1,40	107,0	1,87	107,0	2,33	107,0	2,80	107,0	3,27	107
108,0	0,47	108,0	0,95	108,0	1,41	108,0	1,89	108,0	2,36	108,0	2,83	108,0	3,30	108
109,0	0,48	109,0	0,95	109,0	1,43	109,0	1,90	109,0	2,38	109,0	2,85	109,0	3,33	109
110,0	0,48	110,0	0,96	110,0	1,44	110,0	1,92	110,0	2,40	110,0	2,88	110,0	3,36	110
111,0	0,48	111,0	0,97	111,0	1,45	111,0	1,94	111,0	2,42	111,0	2,91	111,0	3,39	111
112,0	0,49	112,0	0,98	112,0	1,47	112,0	1,96	112,0	2,44	112,0	2,93	112,0	3,42	112
113,0	0,49	113,0	0,99	113,0	1,48	113,0	1,97	113,0	2,47	113,0	2,96	113,0	3,45	113
114,0	0,50	114,0	0,99	114,0	1,49	114,0	1,99	114,0	2,49	114,0	2,98	114,0	3,48	114
115,0	0,5	115,0	1,00	115,0	1,51	115,0	2,01	115,0	2,51	115,0	3,01	115,0	3,51	115
116,0	0,	116,	1,01	116,0	1,52	116,0	2,03	116,0	2,53	116,0	3,04	116,0	3,54	116
117,0	0,51	117,0	1,02	117,0	1,53	117,0	2,04	117,0	2,55	117,0	3,06	117,0	3,57	117
118,0	0,5	118,	1,03	118,0	1,54	118,0	2,06	118,0	2,57	118,0	3,09	118,0	3,60	118
119,0	0,52	119,0	1,04	119,0	1,56	119,0	2,08	119,0	2,60	119,0	3,12	119,0	3,63	119
120,0	0,52	[illegible]	,05	120,0	1,57	120,0	2,09	120,0	2,61	120,0	3,14	120,0	3,6	120
Dep.	Lat	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Diſtance
45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
89 Degrees								88 Degrees						

TRAVERSE TABLE, *712!*

Distance	2 Degrees								3 Degrees							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min		15 Min.		30 Min.		45 Mi	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	D
1	1,00	0,04	1,00	0,04	1,00	0,04	1,00	0,05	1,00	0,05	1,00	0,06	1,00	0,06	1,00	
2	2,00	0,07	2,00	0,08	2,00	0,09	2,00	0,10	2,00	0,11	2,00	0,11	2,00	0,12	2,00	
3	3,00	0,11	3,00	0,12	3,00	0,13	3,00	0,14	3,00	0,16	3,00	0,17	2,99	0,18	2,99	
4	4,00	0,14	4,00	0,16	4,00	0,18	4,00	0,19	4,00	0,21	4,00	0,23	3,99	0,24	3,99	
5	5,00	0,18	5,00	0,20	5,00	0,22	4,99	0,24	4,99	0,26	4,99	0,28	4,99	0,31	4,99	
6	6,00	0,21	6,00	0,24	5,99	0,26	5,99	0,29	5,99	0,31	5,99	0,34	5,99	0,37	5,99	
7	7,00	0,24	7,00	0,28	6,99	0,31	6,99	0,34	6,99	0,37	6,99	0,40	6,99	0,43	6,99	
8	7,99	0,28	7,99	0,31	7,99	0,35	7,99	0,38	7,99	0,42	7,99	0,45	7,99	0,49	7,98	
9	8,99	0,31	8,99	0,35	8,99	0,39	8,99	0,43	8,99	0,47	8,99	0,51	8,98	0,55	8,98	
10	9,99	0,35	9,99	0,39	9,99	0,44	9,99	0,48	9,99	0,52	9,99	0,57	9,98	0,61	9,98	
11	10,99	0,38	10,99	0,43	10,99	0,48	10,99	0,53	10,99	0,58	10,98	0,62	10,98	0,67	10,98	
12	11,99	0,42	11,99	0,47	11,99	0,52	11,99	0,58	11,98	0,63	11,98	0,68	11,98	0,73	11,97	
13	12,99	0,45	12,99	0,51	12,99	0,57	12,99	0,62	12,98	0,68	12,98	0,74	12,98	0,79	12,97	
14	13,99	0,49	13,99	0,55	13,99	0,61	13,98	0,67	13,98	0,73	13,98	0,79	13,97	0,86	13,97	
15	14,99	0,52	14,99	0,59	14,99	0,65	14,98	0,72	14,98	0,79	14,98	0,85	14,97	0,92	14,97	
16	15,99	0,56	15,99	0,63	15,99	0,70	15,98	0,77	15,98	0,84	15,97	0,91	15,97	0,98	15,97	
17	16,99	0,59	16,99	0,67	16,98	0,74	16,98	0,82	16,98	0,89	16,97	0,96	16,97	1,04	16,96	
18	17,99	0,63	17,99	0,71	17,98	0,79	17,98	0,86	17,98	0,94	17,97	1,02	17,97	1,10	17,96	
19	18,99	0,66	18,99	0,75	18,98	0,83	18,98	0,91	18,98	0,99	18,97	1,08	18,96	1,16	18,96	
20	19,99	0,70	19,99	0,79	19,98	0,87	19,98	0,96	19,97	1,05	19,97	1,13	19,96	1,22	19,96	
21	20,99	0,73	20,99	0,83	20,98	0,92	20,98	1,01	20,97	1,10	20,97	1,19	20,96	1,28	20,96	
22	21,99	0,77	21,98	0,86	21,98	0,96	21,98	1,06	21,97	1,15	21,97	1,25	21,96	1,34	21,95	
23	22,99	0,80	22,98	0,90	22,98	1,00	22,97	1,10	22,97	1,20	22,96	1,30	22,96	1,40	22,95	
24	23,99	0,84	23,98	0,94	23,98	1,05	23,97	1,15	23,97	1,26	23,96	1,36	23,96	1,47	23,95	
25	24,99	0,87	24,98	0,98	24,98	1,09	24,97	1,20	24,97	1,31	24,96	1,42	24,95	1,53	24,95	
26	25,98	0,91	25,98	1,02	25,98	1,13	25,97	1,25	25,97	1,36	25,96	1,47	25,95	1,59	25,94	
27	26,98	0,94	26,98	1,06	26,97	1,18	26,97	1,30	26,96	1,41	26,96	1,53	26,95	1,65	26,94	
28	27,98	0,98	27,98	1,10	27,97	1,22	27,97	1,34	27,96	1,47	27,96	1,59	27,95	1,71	27,94	
29	28,98	1,01	28,98	1,14	28,97	1,27	28,97	1,39	28,96	1,52	28,95	1,64	28,95	1,77	28,94	
30	29,98	1,05	29,98	1,18	29,97	1,31	29,97	1,44	29,96	1,57	29,95	1,70	29,94	1,83	29,94	
31	30,98	1,08	30,98	1,22	30,97	1,35	30,97	1,49	30,96	1,62	30,95	1,76	30,94	1,89	30,93	
32	31,98	1,12	31,98	1,26	31,97	1,40	31,96	1,54	31,96	1,68	31,95	1,81	31,94	1,95	31,93	
33	32,98	1,15	32,98	1,30	32,97	1,44	32,96	1,58	32,96	1,73	32,95	1,87	32,94	2,01	32,93	
34	33,98	1,19	33,97	1,34	33,97	1,48	33,96	1,63	33,96	1,78	33,95	1,93	33,94	2,08	33,93	
35	34,98	1,22	34,97	1,37	34,97	1,53	34,96	1,68	34,95	1,83	34,94	1,99	34,94	2,14	34,92	
36	35,98	1,26	35,97	1,41	35,97	1,57	35,96	1,73	35,95	1,88	35,94	2,04	35,93	2,20	35,92	
37	36,98	1,29	36,97	1,45	36,97	1,61	36,96	1,78	36,95	1,94	36,94	2,10	36,93	2,26	36,92	
38	37,98	1,33	37,97	1,49	37,96	1,66	37,96	1,82	37,95	1,99	37,94	2,16	37,93	2,32	37,92	
39	38,98	1,36	38,97	1,53	38,96	1,70	38,96	1,87	38,95	2,04	38,94	2,21	38,93	2,38	38,92	
40	39,98	1,40	39,97	1,57	39,96	1,75	39,95	1,92	39,95	2,09	39,94	2,27	39,93	2,44	39,91	
41	40,98	1,43	40,97	1,61	40,96	1,79	40,95	1,97	40,94	2,15	40,93	2,33	40,92	2,50	40,91	
42	41,97	1,47	41,97	1,65	41,96	1,83	41,95	2,02	41,94	2,20	41,93	2,38	41,92	2,56	41,91	
43	42,97	1,50	42,97	1,69	42,96	1,88	42,95	2,06	42,94	2,25	42,93	2,44	42,92	2,63	42,91	
44	43,97	1,54	43,97	1,73	43,96	1,93	43,95	2,11	43,94	2,30	43,93	2,50	43,92	2,69	43,91	
45	44,97	1,57	44,97	1,77	44,96	1,96	44,95	2,16	44,94	2,36	44,93	2,55	44,92	2,75	44,90	
46	45,97	1,61	45,97	1,81	45,96	2,01	45,95	2,21	45,94	2,41	45,93	2,61	45,91	2,81	45,90	
47	46,97	1,64	46,97	1,85	46,96	2,05	46,95	2,26	46,94	2,47	46,93	2,67	46,91	2,87	46,90	
48	47,97	1,68	47,96	1,88	47,95	2,09	47,95	2,30	47,94	2,51	47,92	2,72	47,91	2,93	47,90	
49	48,97	1,71	48,96	1,92	48,95	2,14	48,94	2,35	48,93	2,57	48,92	2,78	48,91	2,99	48,90	
50	49,97	1,75	49,96	1,96	49,95	2,18	49,94	2,40	49,93	2,62	49,92	2,84	49,91	3,05	49,89	
51	50,97	1,78	50,96	2,00	50,95	2,23	50,94	2,45	50,93	2,67	50,92	2,89	50,90	3,11	50,89	
52	51,97	1,82	51,96	2,04	51,95	2,27	51,94	2,50	51,93	2,72	51,92	2,95	51,90	3,18	51,89	
53	52,97	1,85	52,96	2,08	52,95	2,31	52,94	2,54	52,93	2,77	52,92	3,01	52,90	3,24	52,89	
54	53,97	1,89	53,96	2,12	53,95	2,36	53,94	2,59	53,93	2,83	53,91	3,06	53,90	3,30	53,88	
55	54,97	1,92	54,96	2,16	54,95	2,40	54,94	2,64	54,92	2,88	54,91	3,12	54,90	3,36	54,88	
56	55,97	1,95	55,96	2,20	55,95	2,44	55,94	2,69	55,92	2,93	55,91	3,18	55,90	3,42	55,88	
57	56,97	1,99	56,96	2,24	56,95	2,49	56,93	2,74	56,92	2,98	56,91	3,23	56,89	3,48	56,88	
58	57,97	2,02	57,96	2,28	57,95	2,53	57,93	2,78	57,92	3,04	57,91	3,29	57,89	3,54	57,88	
59	58,96	2,06	58,96	2,32	58,94	2,57	58,93	2,83	58,92	3,09	58,91	3,35	58,89	3,60	58,87	
60	59,96	2,09	59,95	2,36	59,94	2,62	59,93	2,88	59,92	3,14	59,90	3,40	59,89	3,66	59,87	
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min		45 Min.		30 Min.		15 M	
	88 Deg.		87 Degrees								86 Degrees					

2 Degrees							3 Degrees								Distance
Min	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
2,13	60,95	2,40	60,94	2,66	60,93	2,93	60,92	3,19	60,90	3,46	60,89	3,72	60,87	3,99	61
2,16	61,95	2,43	61,94	2,70	61,93	2,98	61,92	3,25	61,90	3,51	61,88	3,79	61,87	4,06	62
2,20	62,95	2,47	62,94	2,75	62,93	3,02	62,92	3,30	62,90	3,57	62,88	3,85	62,87	4,12	63
2,23	63,95	2,51	63,94	2,79	63,93	3,07	63,91	3,35	63,90	3,63	63,88	3,91	63,86	4,19	64
2,27	64,95	2,55	64,94	2,84	64,93	3,12	64,91	3,40	64,90	3,69	64,88	3,97	64,86	4,25	65
2,30	65,95	2,59	65,94	2,88	65,92	3,17	65,91	3,46	65,89	3,74	65,88	4,03	65,86	4,32	66
2,34	66,95	2,63	66,94	2,92	66,92	3,22	66,91	3,51	66,89	3,80	66,88	4,09	66,86	4,38	67
2,37	67,95	2,67	67,94	2,97	67,92	3,26	67,91	3,56	67,89	3,86	67,87	4,16	67,86	4,45	68
2,4	68,95	2,71	68,94	3,01	68,92	3,31	68,91	3,61	68,89	3,91	68,87	4,22	68,85	4,51	69
2,44	69,95	2,75	69,93	3,05	69,92	3,36	69,91	3,66	69,89	3,97	69,87	4,28	69,85	4,58	70
2,48	70,95	2,79	70,93	3,10	70,92	3,41	70,90	3,72	70,89	4,03	70,87	4,34	70,85	4,64	71
2,51	71,95	2,83	71,93	3,14	71,92	3,46	71,90	3,77	71,88	4,08	71,87	4,40	71,85	4,71	72
2,55	72,94	2,87	72,93	3,18	72,92	3,50	72,90	3,82	72,88	4,14	72,86	4,46	72,84	4,77	73
2,58	73,94	2,91	73,93	3,23	73,92	3,55	73,90	3,87	73,88	4,20	73,86	4,52	73,84	4,84	74
2,61	74,94	2,94	74,93	3,27	74,92	3,60	74,90	3,93	74,88	4,25	74,86	4,58	74,84	4,91	75
2,65	75,94	2,98	75,93	3,31	75,91	3,65	75,90	3,98	75,88	4,31	75,86	4,64	75,84	4,97	76
2,69	76,94	3,02	76,93	3,36	76,91	3,70	76,90	4,03	76,88	4,37	76,86	4,70	76,84	5,04	77
2,73	77,94	3,06	77,93	3,40	77,91	3,74	77,89	4,08	77,87	4,42	77,85	4,76	77,83	5,10	78
2,76	78,94	3,10	78,93	3,45	78,91	3,79	78,89	4,14	78,87	4,48	78,85	4,82	78,83	5,17	79
2,79	79,94	3,14	79,93	3,49	79,91	3,84	79,89	4,19	79,87	4,54	79,85	4,88	79,83	5,23	80
2,83	80,94	3,18	80,92	3,53	80,91	3,89	80,89	4,24	80,87	4,59	80,85	4,95	80,83	5,30	81
2,86	81,94	3,22	81,92	3,58	81,91	3,94	81,89	4,29	81,87	4,65	81,85	5,01	81,83	5,36	82
2,90	82,94	3,26	82,92	3,62	82,91	3,98	82,89	4,34	82,87	4,71	82,84	5,07	82,82	5,43	83
2,93	83,94	3,30	83,92	3,66	83,91	4,03	83,89	4,40	83,87	4,76	83,84	5,13	83,82	5,49	84
2,97	84,94	3,34	84,92	3,71	84,90	4,08	84,88	4,45	84,86	4,82	84,84	5,19	84,82	5,56	85
3,0	85,93	3,38	85,92	3,75	85,90	4,13	85,88	4,50	85,86	4,88	85,84	5,25	85,82	5,62	86
3,04	86,93	3,42	86,92	3,79	86,90	4,18	86,88	4,55	86,86	4,93	86,84	5,31	86,81	5,69	87
3,07	87,93	3,46	87,92	3,84	87,90	4,22	87,88	4,61	87,86	4,99	87,84	5,37	87,81	5,76	88
3,11	88,93	3,49	88,92	3,88	88,90	4,27	88,88	4,66	88,86	5,05	88,83	5,43	88,81	5,82	89
3,14	89,93	3,53	89,92	3,93	89,90	4,32	89,88	4,71	89,86	5,10	89,83	5,50	89,81	5,89	90
3,18	90,93	3,57	90,91	3,97	90,90	4,37	90,88	4,76	90,85	5,17	90,83	5,56	90,81	5,95	91
3,21	91,93	3,61	91,91	4,01	91,90	4,41	91,87	4,82	91,85	5,22	91,83	5,62	91,80	6,02	92
3,25	92,93	3,65	92,91	4,05	92,89	4,46	92,87	4,87	92,85	5,27	92,83	5,68	92,80	6,08	93
3,28	93,93	3,69	93,91	4,10	93,89	4,51	93,87	4,92	93,85	5,33	93,83	5,74	93,80	6,15	94
3,32	94,93	3,73	94,91	4,14	94,89	4,56	94,87	4,97	94,85	5,39	94,82	5,80	94,80	6,21	95
3,35	95,93	3,77	95,91	4,19	95,89	4,61	95,87	5,03	95,85	5,44	95,82	5,86	95,79	6,28	96
3,39	96,93	3,81	96,91	4,23	96,89	4,65	96,87	5,08	96,84	5,50	96,82	5,92	96,79	6,34	97
3,42	97,93	3,85	97,91	4,28	97,89	4,70	97,87	5,13	97,84	5,55	97,82	5,98	97,79	6,41	98
3,46	98,92	3,89	98,91	4,32	98,89	4,75	98,87	5,18	98,84	5,61	98,82	6,04	98,79	6,48	99
3,49	99,92	3,93	99,91	4,36	99,89	4,80	99,86	5,23	99,84	5,67	99,81	6,11	99,79	6,54	100
3,53	100,9	3,97	100,9	4,41	100,9	4,85	100,9	5,29	100,8	5,73	100,8	6,17	100,8	6,61	101
3,56	101,9	4,01	101,9	4,45	101,9	4,89	101,9	5,34	101,8	5,78	101,8	6,23	101,8	6,67	102
3,60	102,9	4,04	102,9	4,49	102,9	4,94	102,9	5,39	102,8	5,84	102,8	6,29	102,8	6,74	103
3,63	103,9	4,08	103,9	4,54	103,9	4,99	103,9	5,44	103,8	5,90	103,8	6,35	103,8	6,80	104
3,67	104,9	4,12	104,9	4,58	104,9	5,04	104,9	5,50	104,8	5,95	104,8	6,41	104,8	6,87	105
3,70	105,9	4,16	105,9	4,62	105,9	5,09	105,9	5,55	105,8	6,01	105,8	6,47	105,8	6,93	106
3,73	106,9	4,20	106,9	4,67	106,9	5,13	106,9	5,60	106,8	6,07	106,8	6,53	106,8	7,00	107
3,77	107,9	4,24	107,9	4,71	107,9	5,18	107,9	5,65	107,8	6,12	107,8	6,59	107,8	7,06	108
3,80	108,9	4,28	108,9	4,76	108,9	5,23	108,9	5,71	108,8	6,18	108,8	6,66	108,8	7,13	109
3,84	109,9	4,32	109,9	4,80	109,9	5,28	109,9	5,76	109,8	6,24	109,8	6,72	109,8	7,19	110
3,87	110,9	4,36	110,9	4,84	110,9	5,33	110,8	5,81	110,8	6,29	110,8	6,78	110,8	7,26	111
3,91	111,9	4,40	111,9	4,89	111,9	5,37	111,8	5,86	111,8	6,35	111,8	6,84	111,8	7,33	112
3,94	112,9	4,44	112,9	4,93	112,9	5,42	112,8	5,92	112,8	6,41	112,8	6,90	112,8	7,39	113
3,98	113,9	4,48	113,9	4,97	113,9	5,47	113,8	5,97	113,8	6,48	113,8	6,96	113,8	7,46	114
4,01	114,9	4,51	114,9	5,02	114,9	5,52	114,8	6,02	114,8	6,52	114,8	7,02	114,8	7,52	115
4,05	115,9	4,55	115,9	5,06	115,9	5,57	115,8	6,07	115,8	6,58	115,8	7,08	115,8	7,59	116
4,08	116,9	4,59	116,9	5,10	116,9	5,62	116,8	6,12	116,8	6,63	116,8	7,14	116,8	7,65	117
4,12	117,9	4,63	117,9	5,15	117,9	5,66	117,8	6,18	117,8	6,69	117,8	7,20	117,7	7,72	118
4,15	118,9	4,67	118,9	5,19	118,9	5,71	118,8	6,23	118,8	6,75	118,8	7,27	118,7	7,78	119
4,19	119,9	4,71	119,9	5,23	119,9	5,76	119,8	6,28	119,8	6,80	119,8	7,33	119,7	7,85	120
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Distance
Min	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
Deg.	87 Degrees								86 Degrees						

Diſtance	4 Degrees								5 Degrees						
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 M
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
1	1,00	0,07	1,00	0,07	1,00	0,07	1,00	0,08	1,00	0,09	1,00	0,09	1,00	0,10	1,00
2	2,00	0,14	2,00	0,15	1,99	0,16	1,99	0,17	1,99	0,17	1,99	0,18	1,99	0,19	1,99
3	2,99	0,21	2,99	0,22	2,99	0,24	2,99	0,25	2,99	0,26	2,99	0,28	2,99	0,29	2,99
4	3,99	0,28	3,99	0,30	3,99	0,31	3,99	0,33	3,99	0,35	3,98	0,37	3,98	0,38	3,98
5	4,99	0,35	4,99	0,37	4,99	0,39	4,98	0,41	4,98	0,44	4,98	0,46	4,98	0,48	4,98
6	5,99	0,42	5,98	0,45	5,98	0,47	5,98	0,49	5,98	0,52	5,98	0,55	5,97	0,58	5,97
7	6,98	0,49	6,98	0,52	6,98	0,55	6.98	0,58	6,97	0,61	6,97	0,64	6,97	0,67	6,97
8	7,98	0,56	7,98	0,59	7,98	0,63	7,97	0,66	7,97	0,70	7,97	0,73	7,96	0,78	7,96
9	8,98	0,63	8,98	0,67	8,97	0,71	8,97	0,75	8,97	0,78	8,96	0,82	8,96	0,86	8,96
10	9,98	0,70	9,97	0,74	9,97	0,79	9,97	0,83	9,96	0,87	9,96	0,92	9,95	0,96	9,95
11	10,97	0,77	10,97	0,82	10,97	0,86	10,96	0,91	10,96	0,96	10,95	1,01	10,95	1,05	10,95
12	11,97	0,84	11,97	0,89	11,96	0,94	11,96	0,99	11,95	1,05	11,95	1,10	11,95	1,15	11,94
13	12,97	0,91	12,97	0,96	12,96	1,02	12,96	1,08	12,95	1,13	12,95	1,19	12,94	1,25	12,94
14	13,97	0,98	13,96	1,04	13,96	1,10	13,95	1,16	13,95	1,22	13,94	1,28	13,94	1,34	13,93
15	14,96	1,05	14,96	1,11	14,95	1,18	14,95	1,24	14,94	1,31	14,94	1,37	14,93	1,44	14,93
16	15,96	1,12	15,96	1,19	15,95	1,26	15,95	1,33	15,94	1,40	15,93	1,46	15,93	1,53	15,92
17	16,96	1,19	16,95	1,26	16,95	1,33	16,94	1,41	16,94	1,48	16,93	1,56	16,92	1,63	16,92
18	17,96	1,26	17,95	1,33	17,94	1,41	17,94	1,49	17,93	1,57	17,92	1,65	17,92	1,73	17,91
19	18,95	1,33	18,95	1,40	18,94	1,49	18,93	1,57	18,93	1,66	18,92	1,74	18,91	1,82	18,91
20	19,95	1,40	19,95	1,48	19,94	1,57	19,93	1,66	19,92	1,74	19,91	1,83	19,91	1,92	19,90
21	20,95	1,47	20,94	1,56	20,94	1,65	20,93	1,74	20,92	1,83	20,91	1,92	20,90	2,01	20,89
22	21,95	1,54	21,94	1,63	21,93	1,73	21,93	1,82	21,92	1,92	21,91	2,01	21,90	2,11	21,89
23	22,94	1,60	22,94	1,70	22,93	1,80	22,92	1,90	22,91	2,00	22,90	2,11	22,89	2,21	22,88
24	23,94	1,67	23,93	1,78	23,93	1,88	23,92	1,99	23,91	2,09	23,90	2,20	23,89	2,30	23,88
25	24,94	1,74	24,93	1,8[illegible]	24,92	1,96	24,91	2,07	24,91	2,18	24,90	2,29	24,89	2,40	24,87
26	25,94	1,81	25,93	1,93	25,92	2,04	25,91	2,15	25,90	2,27	25,89	2,38	25,88	2,49	25,87
27	26,93	1,88	26,93	2,00	26,92	2,12	26,91	2,24	26,90	2,35	26,89	2,47	26,88	2,59	26,86
28	27,93	1,95	27,92	2,08	27,91	2,20	27,90	2,32	27,89	2,44	27,88	2,56	27,87	2,68	27,86
29	28,93	2,02	28,92	2,15	28,91	2,28	28,90	2,40	28,89	2,53	28,88	2,65	28,87	2,78	28,85
30	29,93	2,09	29,92	2,22	29,91	2,35	29,90	2,48	29,89	2,62	29,87	2,75	29,86	2,88	29,85
31	30,93	2,16	30,92	2,30	30,91	2,43	30,89	2,57	30,88	2,70	30,87	2,84	30,86	2,97	30,84
32	31,92	2,23	31,91	2,37	31,90	2,51	31,89	2,65	31,88	2,79	31,87	2,93	31,85	3,07	31,84
33	32,92	2,30	32,91	2,45	32,90	2,59	32,89	2,73	32,88	2,88	32,86	3,02	32,85	3,17	32,83
34	33,92	2,37	33,91	2,52	33,90	2,67	33,88	2,82	33,87	2,96	33,86	3,11	33,85	3,26	33,83
35	34,92	2,44	34,90	2,59	34,89	2,75	34,88	2,90	34,87	3,05	34,85	3,20	34,84	3,36	34,82
36	35,91	2,51	35,90	2,67	35,89	2,83	35,88	2,98	35,86	3,14	35,85	3,29	35,84	3,45	35,82
37	36,91	2,58	36,90	2,74	36,89	2,90	36,87	3,06	36,86	3,23	36,85	3,39	36,83	3,55	36,81
38	37,91	2,65	37,90	2,82	37,88	2,98	37,87	3,15	37,86	3,31	37,84	3,48	37,83	3,64	37,81
39	38,91	2,72	38,89	2,89	38,88	3,06	38,87	3,23	38,85	3,40	38,84	3,57	38,82	3,74	38,80
40	39,90	2,79	39,89	2,96	39,88	3,14	39,86	3,31	39,85	3,49	39,83	3,66	39,82	3,83	39,80
41	40,90	2,86	40,89	3,04	40,87	3,22	40,86	3,40	40,84	3,57	40,83	3,75	40,81	3,93	40,79
42	41,90	2,93	41,89	3,11	41,87	3,30	41,86	3,48	41,84	3,66	41,82	3,84	41,81	4,03	41,79
43	42,90	3,00	42,88	3,19	42,87	3,37	42,85	3,56	42,84	3,75	42,82	3,94	42,80	4,12	42,78
44	43,89	3,07	43,88	3,26	43,87	3,45	43,85	3,64	43,83	3,84	43,82	4,03	43,80	4,22	43,78
45	44,89	3,14	44,88	3,34	44,86	3,53	44,85	3,73	44,83	3,92	44,81	4,12	44,79	4,31	44,77
46	45,89	3,21	45,87	3,41	45,86	3,61	45,84	3,81	45,83	4,00	45,81	4,21	45,79	4,41	45,77
47	46,89	3,28	46,87	3,48	46,86	3,69	46,84	3,89	46,82	4,10	46,80	4,30	46,78	4,51	46,76
48	47,88	3,35	47,87	3,56	47,85	3,77	47,84	3,97	47,82	4,18	47,80	4,39	47,78	4,60	47,76
49	48,88	3,42	48,87	3,63	48,85	3,84	48,83	4,06	48,81	4,27	48,79	4,48	48,78	4,70	48,75
50	49,88	3,49	49,86	3,71	49,85	3,02	49,83	4,14	49,81	4,36	49,79	4,58	49,77	4,79	49,75
51	50,88	3,56	50,86	3,78	50,84	4,00	50,83	4,22	50,81	4,45	50,79	4,67	50,77	4,89	50,74
52	51,87	3,63	51,86	3,85	51,84	4,08	51,82	4,31	51,80	4,53	51,78	4,76	51,76	4,99	51,74
53	52,87	3,70	52,86	3,93	52,84	4,16	52,82	4,39	52,80	4,62	52,78	4,85	52,76	5,08	52,73
54	53,87	3,77	53,85	4,00	53,83	4,24	53,82	4,47	53,80	4,71	53,77	4,94	53,75	5,18	53,73
55	54,87	3,84	54,85	4,08	4,83	4,32	54,81	4,56	54,79	4,79	54,77	5,03	54,75	5,27	54,72
56	55,86	3,9[illegible]	55,85	4,15	55,83	4,39	55,81	4,64	55,79	4,88	55,77	5,12	55,74	5,37	55,72
57	56,86	3,98	56,84	4,23	56,82	4,47	56,81	4,72	56,78	4,97	56,76	5,22	56,74	5,46	56,71
58	57,86	4,05	57,84	4,30	57,82	4,55	57,80	4,80	57,78	5,06	57,76	5,31	57,73	5,56	57,71
59	58,86	4,12	58,84	4,37	58,82	4,63	58,80	4,89	58,78	5,15	58,75	5,40	58,73	5,66	58,70
60	59,85	4,19	59,84	4,4[illegible]	9,82	4,7[illegible]	59,79	4,97	9,77	5,23	59,75	5,49	59,72	5,75	59,70
Diſtance	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	1 at.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		45 Min.		30 in.		1: Min		0 Min.		45 Min.		30 Min.		15 M
	86 Deg.		85 Degrees								84 Degrees				

4 Degrees								5 Degrees								
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		Distance.
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	
0,85	4,26	60,83	4,52	60,81	4,79	60,79	5,05	60,77	5,32	60,74	5,58	60,72	5,85	60,69	6,11	61
1,85	4,33	61,83	4,60	61,81	4,87	61,79	5,14	61,76	5,40	61,74	5,67	61,72	5,94	61,69	6,21	62
2,85	4,40	62,83	4,67	62,81	4,94	62,78	5,22	62,76	5,49	62,74	5,77	62,71	6,04	62,68	6,31	63
3,84	4,47	63,82	4,74	63,80	5,02	63,78	5,30	63,76	5,58	63,73	5,86	63,71	6,13	63,68	6,41	64
4,84	4,54	64,82	4,81	64,80	5,10	64,78	5,38	64,75	5,67	64,73	5,95	64,70	6,23	64,67	6,51	65
5,84	4,61	65,82	4,89	65,80	5,18	65,77	5,47	65,75	5,75	65,72	6,04	65,70	6,33	65,67	6,61	66
6,84	4,67	66,82	4,97	66,79	5,26	66,77	5,55	66,74	5,84	66,72	6,13	66,69	6,42	66,66	6,71	67
7,83	4,74	67,81	5,04	67,79	5,34	67,77	5,63	67,74	5,93	67,71	6,22	67,69	6,52	67,66	6,81	68
8,83	4,81	68,81	5,11	68,79	5,41	68,76	5,71	68,74	6,02	68,71	6,31	68,68	6,61	68,65	6,91	69
9,83	4,88	69,81	5,19	69,78	5,49	69,76	5,80	69,73	6,10	69,71	6,41	69,68	6,71	69,65	7,01	70
0,83	4,95	70,81	5,26	70,78	5,57	70,76	5,88	70,73	6,19	70,70	6,50	70,67	6,81	70,64	7,11	71
1,82	5,02	71,80	5,34	71,78	5,65	71,75	5,96	71,73	6,28	71,70	6,59	71,67	6,90	71,64	7,21	72
2,82	5,09	72,80	5,41	72,78	5,73	72,75	6,04	72,72	6,36	72,69	6,68	72,66	7,00	72,63	7,31	73
3,82	5,16	73,80	5,48	73,77	5,81	73,75	6,13	73,72	6,45	73,69	6,77	73,66	7,09	73,63	7,41	74
4,82	5,23	74,79	5,56	74,77	5,88	74,74	6,21	74,71	6,54	74,69	6,86	74,66	7,19	74,62	7,51	75
5.81	5,30	75,79	5,63	75,77	5,96	75,74	6,29	75,71	6,62	75,68	6,95	75,65	7,29	75,61	7,61	76
6,81	5,37	76,79	5,71	76,76	6,04	76,74	6,38	76,71	6,71	76,68	7,05	76,65	7,38	76,61	7,71	77
7,81	5,44	77,76	5,78	77,76	6,12	77,73	6,46	77,70	6,80	77,67	7,14	77,64	7,48	77,61	7,81	78
8,81	5,51	78,78	5,86	78,76	6,20	78,73	6,54	78,70	6,89	78,67	7,23	78,64	7,57	78,60	7,91	79
9,81	5,58	79,78	5,93	79,75	6,28	79,73	6,63	79,70	6,97	79,66	7,32	79,63	7,6	79,60	8,01	80
,80	5,65	80,78	6,00	80,75	6,36	80,72	6,71	80,69	7,06	80,66	7,41	80,63	7,76	80,59	8,11	81
,80	5,72	81,78	6,08	81,75	6,43	81,72	6,79	81,69	7,15	81,66	7,50	81,62	7,86	81,59	8,21	82
,80	5,79	82,77	6,15	82,75	6,51	82,72	6,87	82,68	7,24	82,65	7,60	82,62	7,96	82,58	8,3	83
,80	5,86	83,77	6,23	83,74	6,59	83,71	6,96	83,68	7,32	83,65	7,69	83,61	8,05	83,58	8,41	84
,79	5,93	84,77	6,30	84,74	6,67	84,71	7,04	84,68	7,41	84,64	7,78	84,61	8,15	84,57	8,51	85
,79	6,01	85,76	6,37	85,74	6,75	85,71	7,12	85,67	7,50	85,64	7,87	85,61	8,24	85,57	8,61	86
,79	6,07	86,76	6,45	86,73	6,83	86,70	7,21	86,67	7,58	86,63	7,96	86,60	8,34	86,56	8,71	87
,79	6,14	87,76	6,52	87,73	6,91	87,70	7,29	87,67	7,67	87,63	8,05	87,60	8,44	87,56	8,81	88
,78	6,21	88,76	6,60	88,73	6,98	88,70	7,37	88,66	7,76	88,63	8,14	88,59	8,53	88,55	8,91	89
,78	6,28	89,75	6,67	89,72	7,06	89,69	7,45	89,66	7,84	89,62	8,24	89,59	8,63	89,55	9,01	90
,78	6,35	90,75	6,74	90,72	7,14	90,69	7,54	90,65	7,93	90,62	8,33	90,58	8,72	90,54	9,11	91
,78	6,42	91,75	6,82	91,72	7,22	91,68	7,62	91,65	8,02	91,61	8,42	91,58	8,82	91,54	9,21	92
,77	6,49	92,75	6,89	92,71	7,30	92,68	7,70	92,65	8,11	92,61	8,51	92,57	8,92	92,53	9,31	93
,77	6,56	93,74	6,97	93,71	7,38	93,68	7,78	93,64	8,19	93,61	8,60	93,57	9,01	9,353	9,41	94
,77	6,63	94,74	7,04	94,71	7,45	94,67	7,87	94,64	8,28	94,60	8,69	94,56	9,11	94,52	9,51	95
,77	6,70	95,74	7,12	95,71	7,53	95,67	7,95	95,63	8,37	95,60	8,78	95,56	9,20	95,52	9,61	96
,76	6,77	96,73	7,19	96,70	7,61	96,67	8,03	96,63	8,45	96,59	8,88	96,55	9,30	96,51	9,71	97
,76	6,84	97,73	7,26	97,70	7,69	97,66	8,12	97,63	8,54	97,59	8,97	97,55	9,39	97,51	9,81	98
,76	6,91	98,73	7,34	98,70	7,77	98,66	8,20	98,62	8,63	98,59	9,06	98,55	9,49	98,50	9,91	99
,76	6,98	99,73	7,41	99,69	7,85	99,66	8,28	99,62	8,72	99,58	9,15	99,54	9,59	99,50	10,01	100
0,7	7,05	100,7	7,49	100,7	7,92	100,6	8,36	100,6	8,80	100,6	9,24	100,5	9,68	100,5	10,11	101
1,7	7,12	101,7	7,56	101,7	8,00	101,6	8,45	101,6	8,89	101,6	9,33	101,5	9,78	101,5	10,21	102
2,7	7,19	102,7	7,63	102,7	8,08	102,6	8,53	102,6	8,98	102,6	9,43	102,5	9,87	10,25	10,32	103
3,7	7,26	103,7	7,71	103,7	8,16	103,6	8,61	103,6	9,07	103,6	9,52	103,5	9,97	103,5	10,42	104
4,7	7,33	104,7	7,78	104,7	8,24	104,6	8,70	104,6	9,15	104,6	9,61	104,5	10,06	104,5	10,52	105
5,7	7,40	105,7	7,86	105,7	8,32	105,6	8,78	105,5	9,24	105,6	9,70	105,5	10,16	105,5	10,62	106
6,7	7,46	106,7	7,93	106,7	8,40	106,6	8,86	106,5	9,33	106,6	9,79	106,5	10,26	106,5	10,72	107
7,7	7,53	107,7	8,00	107,7	8,47	107,6	8,94	107,5	9,41	107,6	9,88	107,5	10,35	107,5	10,82	108
8,7	7,60	108,7	8,08	108,7	8,55	108,6	9,03	108,5	9,50	108,5	9,97	108,5	10,45	108,5	10,92	109
9,7	7,67	109,7	8,15	109,7	8,63	109,6	9,11	109,5	9,59	109,5	10,07	109,5	10,54	109,4	11,02	110
0,7	7,74	110,7	8,23	110,7	8,71	110,6	9,19	110,5	9,68	110,5	10,16	110,5	10,64	110,4	11,12	111
1,7	7,81	111,7	8,30	111,7	8,79	111,6	9,28	111,5	9,76	111,5	10,25	111,5	10,74	111,4	11,22	112
2,7	7,88	112,7	8,37	112,7	8,87	112,6	9,36	112,5	9,85	112,5	10,34	112,5	10,83	112,4	11,32	113
3,7	7,95	113,7	8,45	113,6	8,95	113,6	9,44	113,5	9,94	113,5	10,43	113,5	10,93	113,4	11,42	114
4,7	8,02	114,7	8,52	114,6	9,02	114,6	9,52	114,5	10,02	114,5	10,52	114,5	11,03	114,4	11,52	115
5,7	8,09	115,7	8,60	115,6	9,10	115,6	9,61	115,5	10,11	115,5	10,61	115,5	11,12	115,4	11,62	116
6,7	8,16	116,7	8,67	116,6	9,18	116,5	9,69	116,5	10,20	116,5	10,71	116,5	11,22	116,4	11,72	117
7,7	8,23	117,7	8,75	117,6	9,26	117,5	9,77	117,5	10,29	117,5	10,80	117,5	11,31	117,4	11,82	118
8,7	8,30	118,7	8,82	118,6	9,34	118,5	9,85	118,5	10,37	118,5	10,89	118,5	11,41	118,4	11,92	119
9,7	8,37	119,7	8,89	119,6	9,42	119,5	9,04	119,5	10,46	119,5	10,08	119,4	11,50	119,4	12,02	120
p.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Distance
Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
Deg.		85 Degrees								84 Degrees						

Diſtance	6 Degrees								7 Degree						
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Mi
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
1	1,00	0,11	1,00	0,11	0,99	0,11	0,99	0,12	0,99	0,12	0,99	0,13	0,99	0,13	0,99
2	1,99	0,21	1,99	0,22	1,99	0,23	1,99	0,24	1,99	0,24	1,98	0,25	1,98	0,26	1,98
3	2,99	0,32	2,98	0,33	2,98	0,34	2,98	0,35	2,98	0,37	2,98	0,38	2,98	0,39	2,97
4	3,98	0,41	3,98	0,44	3,97	0,45	3,97	0,47	3,97	0,49	3,97	0,51	3,97	0,52	3,96
5	4,97	0,52	4,97	0,54	4,97	0,57	4,97	0,59	4,97	0,61	4,96	0,63	4,96	0,65	4,95
6	5,97	0,63	5,96	0,65	5,96	0,68	5,96	0,71	5,96	0,73	5,95	0,76	5,95	0,78	5,95
7	6,96	0,73	6,96	0,76	6,96	0,79	6,95	0,82	6,95	0,85	6,94	0,88	6,94	0,91	6,94
8	7,96	0,84	7,95	0,87	7,95	0,91	7,95	0,94	7,94	0,98	7,94	1,01	7,94	1,04	7,93
9	8,95	0,94	8,95	0,98	8,94	1,02	8,94	1,06	8,93	1,10	8,93	1,14	8,93	1,18	8,92
10	9,95	1,05	9,94	1,09	9,94	1,13	9,93	1,18	9,93	1,22	9,92	1,26	9,92	1,31	9,91
11	10,94	1,15	10,94	1,20	10,93	1,25	10,92	1,29	10,92	1,34	10,91	1,39	10,91	1,44	10,90
12	11,93	1,25	11,93	1,31	11,92	1,36	11,92	1,41	11,91	1,46	11,90	1,51	11,90	1,57	11,89
13	12,93	1,36	12,92	1,42	12,92	1,47	12,91	1,53	12,90	1,58	12,90	1,64	12,90	1,70	12,88
14	13,92	1,46	13,92	1,52	13,91	1,59	13,90	1,65	13,90	1,71	13,89	1,77	13,89	1,83	13,87
15	14,92	1,57	14,91	1,63	14,90	1,70	14,90	1,76	14,89	1,83	14,88	1,89	14,88	1,96	14,86
16	15,91	1,67	15,91	1,74	15,90	1,81	15.89	1,88	15,88	1,95	15,87	2,02	15,87	2,09	15,85
17	16,91	1,78	16,90	1,85	16,89	1,92	16,88	2,00	16,87	2,07	16,86	2,15	16,86	2,22	16,84
18	17,90	1,88	17,89	1,96	17,88	2,04	17,88	2,12	17,87	2,19	17,86	2,27	17,86	2,35	17,83
19	18,90	1,98	18,89	2,07	18,88	2,15	18,87	2,23	18,86	2,32	18,85	2,40	18,85	2,48	18,83
20	19,89	2,09	19,88	2,18	19,87	2,26	19,86	2,35	19,85	2,44	19,84	2,52	19,84	2,61	19,82
21	20,89	2,20	20,88	2,29	20,86	2,38	20,85	2,47	20,84	2,56	20,83	2,64	20,83	2,74	20,81
22	21,88	2,30	21,87	2,39	21,86	2,49	21,85	2,59	21,84	2,68	21,82	2,77	21,82	2,87	21,80
23	22,87	2,41	22,86	2,50	22,85	2,60	22,84	2,70	22,83	2,80	22,82	2,90	22,82	3,00	22,79
24	23,87	2,51	23,86	2,61	23,85	2,72	23,83	2,82	23,82	2,93	23,81	3,03	23,81	3,13	23,78
25	24,86	2,61	24,85	2,72	24,84	2,83	24,83	2,94	24,82	3,05	24,80	3,16	24,80	3,27	24,77
26	25,86	2,72	25,85	2,83	25,83	2,94	25,82	3,06	25,81	3,17	25,79	3,28	25,79	3,40	25,76
27	26,85	2,82	26,84	2,94	26,83	3,06	26,81	3,17	26,80	3,29	26,78	3,41	26,78	3,53	26,75
28	27,85	2,93	27,83	3,05	27,82	3,17	27,81	3,29	27,79	3,41	27,78	3,53	27,78	3,66	27,74
29	28,84	3,03	28,83	3,16	28,81	3,28	28,80	3,41	28,79	3,53	28,77	3,66	28,77	3,79	28,73
30	29,84	3,14	29,82	3,27	29,81	3,40	29,79	3,53	29,78	3,66	29,76	3,79	29,76	3,92	29,73
31	30,83	3,24	30,82	3,38	30,80	3,51	30,79	3,64	30,77	3,78	30,75	3,91	30,75	4,05	30,72
32	31,83	3,35	31,81	3,48	31,79	3,62	31,78	3,76	31,76	3,90	31,74	4,04	31,74	4,18	31,71
33	32,82	3,45	32,80	3,59	32,79	3,74	32,78	3.81	32,76	4,02	32,74	4,17	32,74	4,31	32,70
34	33,81	3,56	33,80	3,70	33,78	3,85	33,77	4,00	33,75	4,14	33,73	4,29	33,73	4,44	33,69
35	34,81	3,66	34,79	3,81	34,78	3,96	34,76	4,11	34,74	4,27	34,72	4,42	34,72	4,57	34,68
36	35,80	3,76	35,79	3,92	35,77	4,08	35,75	4,23	35,73	4,39	35,71	4,54	35,71	4,70	35,67
37	36,80	3,87	36,78	4,03	36,76	4,19	36,75	4,35	36,73	4,51	36,70	4,67	36,70	4,83	36,66
38	37,79	3,97	37,77	4,14	37,76	4,30	37,74	4,47	37,72	4,63	37,70	4,80	37,70	4,96	37,65
39	38,79	4,08	38,77	4,24	38,75	4,42	38,73	4,58	38,71	4,75	38,69	4,92	38,69	5,09	38,64
40	39,78	4,18	39,76	4,36	39,74	4,53	39,72	4,70	39,70	4,88	39,68	5,05	39,68	5,22	39,64
41	40,78	4,29	40,76	4,46	40,74	4,64	40,72	4,82	40,70	5,00	40,67	5,17	40,67	5,35	40,63
42	41,77	4,39	41,75	4,57	41,73	4,76	41,71	4,94	41,69	5,12	41,66	5,30	41,66	5,48	41,62
43	42,77	4,49	42,74	4,68	42,72	4,87	42.70	5,06	42,68	5,24	42,66	5,43	42,66	5,61	42,61
44	43,76	4,60	43,74	4,79	43,72	4,98	43,70	5,17	43,67	5,36	43,65	5,55	43,65	5,74	43,60
45	44,75	4,70	44,73	4,90	44,71	5,10	44,69	5,29	44,67	5,48	44,64	5,68	44,64	5,87	44,59
46	45,75	4,81	45,73	5,01	45,71	5,21	45,68	5,41	45,66	5,61	45,63	5,81	45,63	6,00	45,58
47	46,74	4,91	46,72	5,12	46,70	5,32	46,68	5,52	46,65	5,73	46,62	5,93	46,62	6,14	46,57
48	47,74	5,02	47,71	5,23	47,69	5,43	47,67	5,64	47,64	5,85	47,62	6,06	47,62	6,27	47,56
49	48,73	5,12	48,71	5,34	48,69	5,55	48,66	5,76	48,64	5,97	48,61	6,18	48,61	6,40	48,55
50	49,73	5,23	49,70	5,44	49,68	5,66	49,65	5,88	49,63	6,09	49,60	6,31	49,60	6,53	49,54
51	50,72	5,33	50,70	5,55	50,67	5,77	50,65	6,00	50,62	6,22	50,59	6,44	50,58	6,66	50,54
52	51,72	5,44	51,69	5,66	51,67	5,89	51,64	6,11	51,61	6,34	51,58	6,56	51,59	6,79	51,53
53	52,71	5,54	52,69	5,77	52,66	6,00	52,63	6,23	52,61	6,46	52,58	6,69	52,58	6,92	52,52
54	53,70	5,65	53,68	5,88	53,65	6,11	53,63	6,35	53,60	6,58	53,57	6,82	53,57	7,05	53,51
55	54,70	5,75	54,67	5,99	54,65	6,23	54,62	6,47	54,59	6,70	54,56	6,94	54,56	7,18	54,50
56	55,69	5,85	55,67	6,10	55,64	6,34	55,61	6,58	55,58	6,83	55,55	7,07	55,55	7,31	55,49
57	56,69	5,96	56,66	6,21	56,63	6,45	56,61	6,70	56,58	6,95	56,54	7,19	56,54	7,44	56,48
58	57,68	6,06	57,66	6,31	57,63	6,57	57,60	6,82	57,57	7,07	57,54	7,32	57,54	7,57	57.47
59	58,68	6,17	58,65	6,42	58,62	6,68	58,54	6,94	58,56	7,19	58,53	7,45	58,53	7,70	58,46
60	59,67	6,27	59,64	6,53	59,61	6,79	59,58	7,05	59,55	7,31	59,52	7,57	59,52	7,83	59,45
Diſtance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 M
	82 Deg.		83 Degrees						82 Degrees						

6 Degree								7 Degrees								Diſtance
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
0,67	6,38	60,64	6,64	60,61	6,91	60,58	7,17	60,55	7,43	60,51	7,70	60,48	7,96	60,44	8,23	61
1,66	6,48	61,63	6,78	61,60	7,02	61,57	7,29	61,54	7,56	61,50	7,82	61,47	8,09	61,43	8,36	62
2,66	6,59	62,63	6,86	62,60	7,13	62,56	7,41	62,53	7,68	62,50	7,95	62,46	8,22	62,42	8,50	63
3,65	6,69	63,62	6,97	63,59	7,24	63,56	7,52	63,52	7,80	63,49	8,08	63,45	8,35	63,42	8,63	64
4,64	6,80	64,61	7,08	64,58	7,36	64,55	7,64	64,52	7,92	64,48	8,20	64,44	8,48	64,41	8,77	65
5,64	6,90	65,61	7,19	65,58	7,47	65,55	7,76	65,51	8,04	65,47	8,33	65,44	8,62	65,40	8,90	66
6,63	7,01	66,60	7,29	66,57	7,58	66,54	7,88	66,50	8,17	66,46	8,45	66,43	8,75	66,39	9,04	67
7,63	7,11	67,60	7,40	67,56	7,70	67,53	7,99	67,49	8,29	67,46	8,58	67,42	8,88	67,38	9,17	68
8,62	7,21	68,59	7,51	68,56	7,81	68,52	8,11	68,49	8,41	68,45	8,71	68,41	9,01	68,37	9,31	69
9,62	7,32	69,58	7,62	69,55	7,92	69,52	8,23	69,48	8,53	69,44	8,83	69,40	9,14	69,36	9,44	70
0,61	7,42	70,58	7,73	70,54	8,04	70,51	8,35	70,47	8,65	70,43	8,96	70,39	9,27	70,35	9,58	71
1,61	7,53	71,57	7,84	71,54	8,15	71,50	8,46	71,46	8,77	71,42	9,09	71,38	9,40	71,34	9,71	72
2,60	7,63	72,57	7,95	72,53	8,26	72,49	8,58	72,46	8,90	72,42	9,21	72,37	9,53	72,33	9,84	73
3,59	7,74	73,56	8,06	73,52	8,38	73,49	8,70	73,45	9,02	73,41	9,34	73,37	9,66	73,32	9,98	74
4,59	7,84	74,56	8,17	74,52	8,49	74,48	8,82	74,44	9,14	74,40	9,46	74,36	9,79	74,32	10,11	75
5,58	7,94	75,55	8,27	75,51	8,60	75,47	8,93	75,44	9,26	75,39	9,59	75,35	9,92	75,31	10,25	76
6,58	8,05	76,54	8,38	76,51	8,72	76,47	9,05	76,43	9,38	76,38	9,72	76,34	10,05	76,30	10,38	77
7,57	8,15	77,54	8,49	77,40	8,83	77,46	9,17	77,42	9,51	77,38	9,84	77,33	10,18	77,29	10,52	78
8,57	8,26	78,53	8,61	78,49	8,94	78,45	9,29	78,41	9,63	78,37	9,97	78,32	10,31	78,28	10,65	79
9,56	8,36	79,53	8,71	79,49	9,06	79,45	9,40	79,40	9,75	79,36	10,09	79,32	10,44	79,27	10,79	80
0,56	8,47	80,52	8,82	80,48	9,17	80,44	9,52	80,39	9,87	80,35	10,22	80,31	10,57	80,26	10,92	81
1,55	8,57	81,51	8,93	81,47	9,28	81,43	9,64	81,38	9,99	81,34	10,35	81,30	10,70	81,25	11,06	82
2,55	8,68	82,51	9,04	82,47	9,40	82,43	9,76	82,38	10,12	82,34	10,48	82,29	10,83	82,24	11,19	83
3,54	8,78	83,50	9,15	83,46	9,51	83,42	9,87	83,37	10,24	83,33	10,60	83,28	10,96	83,23	11,33	84
4,53	8,88	84,50	9,25	84,45	9,62	84,41	9,99	84,37	10,36	84,32	10,73	84,27	11,10	84,22	11,46	85
5,53	8,99	85,49	9,36	85,45	9,73	85,40	10,11	85,36	10,48	85,31	10,85	85,26	11,23	85,22	11,60	86
6,52	9,09	86,48	9,47	86,44	9,85	86,40	10,23	86,35	10,60	86,30	10,98	86,26	11,36	86,21	11,73	87
7,52	9,20	87,48	9,58	87,43	9,96	87,39	10,34	87,34	10,73	87,30	11,11	87,25	11,49	87,20	11,87	88
8,51	9,30	88,47	9,69	88,43	10,07	88,38	10,46	88,34	10,85	88,29	11,23	88,24	11,62	88,19	12,00	89
9,51	9,41	89,47	9,80	89,42	10,19	89,38	10,58	89,33	10,97	80,28	11,36	89,23	11,75	89,18	12,14	90
0,50	9,51	90,46	9,91	90,41	10,30	90,37	10,70	90,32	11,09	90,27	11,49	90,22	11,88	90,17	12,27	91
1,50	9,62	91,45	10,02	91,41	10,41	91,36	10,81	91,31	11,21	91,26	11,61	91,21	12,01	91,16	12,41	92
2,49	9,72	92,45	10,13	92,40	10,53	92,36	10,93	92,31	11,33	92,26	11,74	92,20	12,14	92,15	12,54	93
3,49	9,83	93,44	10,23	93,40	10,64	93,35	11,05	93,30	11,46	93,25	11,86	93,20	12,27	93,14	12,68	94
4,48	9,93	94,44	10,34	94,39	10,75	94,34	11,17	94,29	11,58	94,24	11,99	94,19	12,40	94,13	12,81	95
5,47	10,04	95,43	10,45	95,38	10,87	95,34	11,28	95,29	11,70	95,23	12,12	95,18	12,53	95,12	12,95	96
6,47	10,14	96,42	10,56	96,38	10,98	96,33	11,40	96,28	11,82	96,22	12,24	96,17	12,66	96,11	13,08	97
7,46	10,24	97,42	10,67	97,37	11,09	97,32	11,52	97,27	11,94	97,22	12,37	97,16	12,79	97,11	13,22	98
8,46	10,35	98,41	10,78	98,36	11,21	98,31	11,64	98,26	12,07	98,21	12,49	98,15	12,92	98,10	13,35	99
9,45	10,45	99,41	10,89	99,36	11,32	99,31	11,75	99,26	12,19	99,20	12,62	99,14	13,05	99,09	13,49	100
1,4	10,56	101,4	11,00	101,4	11,43	100,3	11,87	101,2	12,31	100,2	12,75	101,1	13,18	100,1	13,62	101
2,4	10,66	102,4	11,11	102,3	11,55	101,3	11,99	102,2	12,43	101,2	12,87	102,1	13,31	101,1	13,75	102
3,4	10,77	103,4	11,21	103,3	11,66	102,3	12,11	103,2	12,55	102,2	13,00	103,1	13,45	102,1	13,89	103
4,4	10,87	104,4	11,32	104,3	11,77	103,3	12,22	104,2	12,68	103,2	13,13	104,1	13,58	103,1	14,02	104
5,4	10,98	105,4	11,43	105,3	11,89	104,3	12,34	105,2	12,80	104,2	13,28	105,1	13,71	104,0	14,16	105
6,4	11,08	106,4	11,54	106,3	12,00	105,3	12,46	106,2	12,92	105,2	13,38	106,1	13,84	105,0	14,30	106
7,4	11,18	107,4	11,65	107,3	12,11	106,3	12,58	107,2	13,04	106,1	13,50	107,1	13,97	106,0	14,43	107
8,4	11,29	108,4	11,76	108,3	12,23	107,3	12,69	108,2	13,16	107,1	13,63	108,1	14,10	107,0	14,56	108
9,4	11,39	109,3	11,87	109,3	12,34	108,2	12,81	109,2	13,28	108,1	13,76	109,1	14,23	108,0	14,70	109
0,4	11,50	110,3	11,98	110,3	12,45	109,2	12,93	110,2	13,41	109,1	13,88	110,0	14,36	109,0	14,83	110
1,4	11,60	111,3	12,08	111,3	12,57	110,2	13,05	111,2	13,53	110,1	14,01	111,0	14,49	110,0	14,97	111
2,4	11,71	112,3	12,19	112,3	12,68	111,2	13,16	112,2	13,65	111,1	14,14	112,0	14,62	111,0	15,10	112
3,4	11,81	113,3	12,30	113,3	12,79	112,2	13,28	113,2	13,77	112,1	14,26	113,0	14,75	112,0	15,24	113
4,4	11,92	114,3	12,41	114,3	12,90	113,2	13,40	114,1	13,89	113,1	14,39	114,0	14,88	113,0	15,37	114
5,4	12,02	115,3	12,52	115,3	13,02	114,2	12,52	115,1	14,01	114,1	14,51	115,0	15,01	114,0	15,51	115
6,4	12,13	116,3	12,63	116,3	13,13	115,2	13,63	116,1	14,14	115,1	14,64	116,0	15,14	114,9	15,64	116
7,4	12,23	117,3	12,74	117,2	13,24	116,2	13,75	117,1	14,26	116,1	14,76	117,0	15,27	115,9	15,78	117
8,4	12,33	118,3	12,85	118,2	13,36	117,2	13,87	118,1	14,38	117,1	14,89	118,0	15,40	116,9	15,91	118
9,4	12,44	119,3	12,95	119,2	13,47	118,2	13,99	119,1	14,50	118,0	15,02	119,0	15,53	117,9	16,05	119
0,3	12,54	120,3	13,06	120,2	13,58	119,2	14,11	120,1	14,62	119,0	15,17	120,0	15,66	118,9	16,18	120
ep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Diſtance
0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
4 Deg.		83 Degrees								82 Degrees						

Diſtance	8 Degrees								9 Degrees							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	De
1	0,99	0,14	0,99	0,14	0,99	0,15	0,99	0,15	0,99	0,26	0,99	0,16	0,99	0,17	0,99	0,
2	1,98	0,28	1,98	0,29	1,98	0,30	1,98	0,30	1,98	0,31	1,97	0,32	1,97	0,33	1,97	0,
3	2,97	0,42	2,97	0,43	2,97	0,44	2,97	0,46	2,96	0,47	2,96	0,48	2,96	0,50	2,96	0,
4	3,96	0,56	3,96	0,57	3,96	0,59	3,95	0,61	3,95	0,63	3,95	0,64	3,95	0,66	3,94	0,
5	4,95	0,70	4,95	0,72	4,95	0,74	4,94	0,76	4,94	0,78	4,94	0,80	4,93	0,83	4,92	0,
6	5,94	0,84	5,94	0,86	5,93	0,88	5,93	0,91	5,93	0,94	5,92	0,96	5,92	0,99	5,91	1,
7	6,93	0,97	6,93	1,00	6,92	1,04	6,92	1,07	6,91	1,10	6,91	1,13	6,90	1,16	6,89	1,
8	7,92	1,11	7,92	1,15	7,91	1,18	7,91	1,22	7,90	1,25	7,90	1,29	7,89	1,32	7,88	1,
9	8,91	1,25	8,91	1,29	8,90	1,33	8,90	1,37	8,89	1,41	8,88	1,45	8,88	1,49	8,86	1,
10	9,90	1,39	9,90	1,44	0,89	1,48	9,88	1,52	9,88	1,56	9,87	1,61	9,86	1,65	9,84	1,
11	10,90	1,53	10,89	1,58	10,88	1,63	10,87	1,67	10,87	1,72	10,86	1,77	10,85	1,82	10,85	1,
12	11,89	1,67	11,88	1,72	11,87	1,77	11,86	1,83	11,85	1,88	11,84	1,93	11,84	1,98	11,83	2,
13	12,88	1,81	12,87	1,87	12,86	1,92	12,85	1,98	12,84	2,03	12,83	2,09	12,82	2,15	12,80	2,
14	13,87	1,95	13,86	2,01	13,85	2,07	13,84	2,13	13,83	2,19	13,82	2,25	13,81	2,31	13,79	2,
15	14,86	2,09	14,85	2,15	14,84	2,22	14,83	2,28	14,82	2,35	14,81	2,41	14,79	2,48	14,78	2,
16	15,84	2,23	15,84	2,30	15,82	2,37	15,81	2,43	15,80	2,50	15,79	2,57	15,78	2,64	15,77	2,
17	16,83	2,37	16,83	2,44	16,81	2,51	16,80	2,59	16,79	2,66	16,78	2,73	16,77	2,81	16,75	2,
18	17,82	2,51	17,81	2,58	17,80	2,66	17,79	2,74	17,78	2,82	17,77	2,89	17,75	2,97	17,74	3,
19	18,81	2,64	18,80	2,73	18,79	2,81	18,78	2,89	18,77	2,97	18,75	3,05	18,74	3,14	18,73	3,
20	19,81	2,78	19,79	2,87	19,78	2,96	19,77	3,04	19,75	3,13	19,74	3,22	19,73	3,30	19,71	3,
21	20,79	2,92	20,78	3,01	20,77	3,10	20,76	3,19	20,74	3,29	20,73	3,38	20,71	3,47	20,70	3,
22	21,78	3,06	21,77	3,16	21,76	3,25	21,74	3,35	21,73	3,44	21,71	3,54	21,70	3,63	21,68	3,
23	22,77	3,21	22,76	3,30	22,75	3,40	22,73	3,50	22,72	3,60	22,70	3,70	22,69	3,80	22,67	3,
24	23,76	3,34	23,75	3,44	23,74	3,55	23,72	3,65	23,71	3,76	23,69	3,86	23,67	3,96	23,65	4,
25	24,75	3,48	24,74	3,59	24,73	3,70	24,71	3,80	24,69	3,91	24,68	4,02	24,66	4,13	24,64	4,
26	25,74	3,62	25,73	3,73	25,71	3,84	25,70	3,95	25,68	4,07	25,66	4,18	25,64	4,29	25,62	4,
27	26,73	3,76	26,72	3,87	26,70	3,99	26,69	4,11	26,67	4,22	26,65	4,34	26,63	4,46	26,61	4,
28	27,72	3,90	27,71	4,02	27,69	4,14	27,67	4,26	27,66	4,38	27,64	4,50	27,61	4,62	27,60	4,
29	28,71	4,04	28,70	4,16	28,68	4,29	28,66	4,41	28,64	4,54	28,62	4,66	28,60	4,79	28,58	4,
30	29,71	4,18	29,69	4,31	29,67	4,43	29,65	4,56	29,63	4,69	29,61	4,82	29,59	4,96	29,57	5,
31	30,70	4,31	30,68	4,45	30,66	4,58	30,64	4,72	30,62	4,85	30,60	4,98	30,58	5,12	30,55	5,
32	31,69	4,45	31,67	4,59	31,65	4,73	31,63	4,87	31,61	5,01	31,58	5,14	31,56	5,29	31,54	5,
33	32,68	4,59	32,66	4,74	32,64	4,88	32,62	5,02	32,59	5,16	32,57	5,31	32,55	5,45	32,52	5,
34	33,67	4,73	33,65	4,88	33,63	5,03	33,61	5,17	33,58	5,32	33,56	5,47	33,53	5,62	33,51	5,
35	34,66	4,87	34,64	5,02	34,62	5,17	34,59	5,33	34,57	5,48	34,55	5,63	34,52	5,78	34,49	5,
36	35,65	5,01	35,63	5,17	35,61	5,32	35,58	5,48	35,56	5,63	35,54	5,79	35,51	5,95	35,48	6,
37	36,64	5,15	36,62	5,31	36,59	5,47	36,57	5,63	36,55	5,79	36,53	5,95	36,49	6,11	36,47	6.
38	37,63	5,29	37,61	5,45	37,58	5,62	37,56	5,78	37,53	5,95	37,52	6,11	37,48	6,28	37,45	6,
39	38,62	5,43	38,60	5,60	38,57	5,76	38,55	5,93	38,52	6,10	38,49	6,27	38,47	6,44	38,44	6,
40	39,61	5,57	39,59	5,74	39,56	5,91	39,53	6,09	39,51	6,26	39,48	6,43	39,45	6,61	39,42	6,
41	40,60	5,71	40,58	5,88	40,55	6,06	40,52	6,24	40,50	6,41	40,47	6,59	40,44	6,77	40,41	6,
42	41,59	5,85	41,57	6,03	41,54	6,21	41,51	6,39	41,48	6,57	41,45	6,75	41,43	6,94	41,39	7,
43	42,58	5,99	42,56	6,17	42,53	6,36	42,50	6,54	42,47	6,73	42,44	6,91	42,41	7,10	42,38	7,
44	43,57	6,12	43,55	6,31	43,52	6,50	43,49	6,69	43,46	6,88	43,43	7,07	43,40	7,27	43,36	7,
45	44,56	6,26	44,54	6,46	44,51	6,60	44,48	6,85	44,45	7,04	44,42	7,23	44,38	7,43	44,35	7,
46	45,55	6,40	45,52	6,60	45,50	6,80	45,46	7,00	45,43	7,20	45,40	7,40	45,37	7,60	45,34	7,
47	46,54	6,54	46,51	6,74	46,48	6,95	46,45	7,15	46,42	7,35	46,39	7,56	46,36	7,76	46,32	7,
48	47,53	6,68	47,50	6,89	47,47	7,09	47,44	7,30	47,41	7,51	47,38	7,72	47,34	7,93	47,31	8,
49	48,52	6,82	48,49	7,03	48,46	7,24	48,43	7,45	48,40	7,66	48,36	7,88	48,33	8,09	48,29	8,
50	49,51	6,96	49,48	7,18	49,45	7,39	49,42	7,61	49,39	7,82	49,35	8,04	49,32	8,26	49,28	8,
51	50,50	7,10	50,47	7,32	50,44	7,54	50,41	7,76	50,37	7,98	50,32	8,20	50,30	8,42	50,26	8,
52	51,49	7,24	51,46	7,46	51,43	7,69	51,40	7,91	51,36	8,14	51,34	8,36	51,29	8,59	51,25	8,
53	52,48	7,38	52,45	7,61	52,42	7,83	52,38	8,06	52,35	8,29	52,31	8,52	52,27	8,75	52,24	8,
54	53,47	7,52	53,44	7,75	53,41	7,98	53,37	8,21	53,34	8,45	53,30	8,68	53,26	8,92	53,22	9,
55	54,47	7,66	54,43	7,89	54,40	8,13	54,36	8,37	54,32	8,60	54,29	8,84	54,25	9,08	54,21	9,
56	55,46	7,79	55,42	8,04	55,39	8,28	55,35	8,52	55,31	8,76	55,27	9,00	55,23	9,25	55,19	9,
57	56,45	7,93	56,41	8,18	56,37	8,43	56,34	8,67	56,30	8,92	56,26	9,16	56,22	9,41	56,18	9,
58	57,44	8,07	57,40	8,32	57,36	8,57	57,33	8,82	57,29	9,07	57,25	9,32	57,21	9,58	57,16	9,
59	58,43	8,21	58,39	8,47	58,35	8,72	58,31	8,98	58,28	9,23	58,23	9,48	58,19	9,74	58,15	9,
60	59,42	8,35	59,38	8,61	59,34	8,87	59,30	9,13	59,26	9,39	59,22	9,62	59,18	9,91	59,13	10,
Diſtance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	La
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min	
	82 Deg.		81 Degrees								80 Degrees					

8 Degrees							9 Degrees								
Min.	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		Distance
Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
8,49	60,37	8,75	60,33	9,02	60,29	9,28	60,25	9,54	60,21	9,81	60,16	10,07	60,12	10,33	61
8,63	61,36	8,90	61,32	9,16	61,28	9,43	61,24	9,70	61,19	9,97	61,15	10,24	61,11	10,50	62
8,77	62,35	9,04	62,31	9,31	62,27	9,58	62,22	9,86	62,18	10,13	62,14	10,40	62,09	10,67	63
8,91	63,34	9,18	63,30	9,46	63,26	9,74	63,21	10,01	63,17	10,29	63,12	10,57	63,08	10,84	64
9,05	64,33	9,33	64,29	9,61	64,24	9,89	64,20	10,17	64,16	10,45	64,11	10,74	64,06	11,01	65
9,19	65,32	9,47	65,28	9,76	65,23	10,04	65,19	10,33	65,14	10,61	65,09	10,90	65,05	11,18	66
9,32	66,31	9,61	66,26	9,90	66,22	10,19	66,18	10,48	66,13	10,77	66,08	11,07	66,03	11,35	67
9,46	67,30	9,76	67,25	10,05	67,21	10,34	67,16	10,64	67,12	10,93	67,07	11,23	67,02	11,52	68
9,60	68,29	9,90	68,24	10,20	68,20	10,50	68,15	10,79	68,10	11,09	68,05	11,40	68,00	11,69	69
9,74	69,28	10,04	69,23	10,35	69,19	10,65	69,14	10,95	69,09	11,25	69,04	11,56	68,99	11,86	70
9,88	70,27	10,19	70,22	10,50	70,17	10,80	70,13	11,11	70,08	11,41	70,03	11,73	69,97	12,02	71
10,02	71,26	10,33	71,21	10,64	71,16	10,95	71,11	11,26	71,06	11,57	71,01	11,89	70,96	12,19	72
10,16	72,25	10,47	72,20	10,79	72,15	11,10	72,10	11,42	72,05	11,74	72,00	12,06	71,95	12,36	73
10,30	73,23	10,62	73,19	10,94	73,14	11,26	73,09	11,58	73,04	11,90	72,99	12,22	72,93	12,52	74
10,44	74,22	10,76	74,18	11,09	74,13	11,41	74,08	11,73	74,03	12,06	73,97	12,39	73,92	12,79	75
10,58	75,21	10,91	75,17	11,24	75,11	11,56	75,07	11,89	75,01	12,22	74,96	12,55	74,90	12,87	76
10,72	76,20	11,05	76,15	11,38	76,10	11,71	76,05	12,05	76,00	12,38	75,94	12,72	75,89	13,04	77
10,86	77,19	11,19	77,14	11,53	77,09	11,86	77,04	12,20	76,99	12,54	76,93	12,88	76,87	13,21	78
10,99	78,18	11,34	78,13	11,68	78,08	12,02	78,03	12,36	77,97	12,70	77,92	13,05	77,86	13,38	79
11,13	79,17	11,48	79,12	11,83	79,07	12,17	79,02	12,51	78,96	12,86	78,90	13,21	78,85	13,55	80
11,27	80,16	11,62	80,11	11,97	80,06	12,32	80,00	12,67	79,95	13,02	79,89	13,38	79,83	13,72	81
11,41	81,15	11,77	81,10	12,12	81,05	12,47	80,99	12,83	80,93	13,18	80,88	13,54	80,82	13,89	82
11,55	82,14	11,91	82,09	12,27	82,03	12,63	81,98	12,98	81,92	13,34	81,86	13,71	81,80	14,06	83
11,69	83,13	12,05	83,08	12,42	83,02	12,78	82,97	13,14	82,91	13,50	82,85	13,87	82,79	14,23	84
11,83	84,12	12,20	84,07	12,56	84,01	12,93	83,95	13,30	83,90	13,66	83,83	14,04	83,77	14,40	85
11,97	85,11	12,34	85,06	12,72	85,00	13,08	84,94	13,45	84,88	13,82	84,82	14,20	84,76	14,57	86
12,11	86,10	12,48	86,05	12,86	85,99	13,23	85,93	13,61	85,87	13,99	85,81	14,37	85,74	14,73	87
12,25	87,09	12,63	87,03	13,01	86,98	13,39	86,92	13,77	86,86	14,15	86,79	14,53	86,73	14,90	88
12,39	88,08	12,77	88,02	13,16	87,97	13,54	87,91	13,92	87,84	14,31	87,78	14,70	87,71	15,07	89
12,53	89,07	12,91	89,01	13,30	88,95	13,69	88,89	14,08	88,83	14,47	88,77	14,86	88,70	15,24	90
12,67	90,06	13,06	90,00	13,45	89,94	13,84	89,88	14,24	89,82	14,63	89,75	15,03	89,69	15,41	91
12,80	91,05	13,20	90,99	13,60	90,93	14,00	90,87	14,39	90,80	14,79	90,74	15,19	90,67	15,58	92
12,94	92,04	13,34	91,98	13,75	91,92	14,15	91,86	14,55	91,79	14,95	91,73	15,36	91,66	15,75	93
13,08	93,03	13,49	92,97	13,89	92,91	14,30	92,84	14,71	92,78	15,11	92,71	15,52	92,64	15,92	94
13,22	94,02	13,63	93,96	14,04	93,89	14,45	93,83	14,86	93,77	15,27	93,70	15,69	93,63	16,09	95
13,36	95,01	13,78	94,95	14,19	94,88	14,60	94,82	15,02	94,75	15,43	94,68	15,86	94,61	16,26	96
13,50	96,00	13,92	95,94	14,34	95,87	14,76	95,81	15,17	95,74	15,59	95,67	16,02	95,60	16,43	97
13,64	96,99	14,06	96,92	14,49	96,86	14,91	96,79	15,33	96,73	15,75	96,66	16,19	96,58	16,60	98
13,78	97,98	14,21	97,91	14,63	97,85	15,06	97,78	15,49	97,71	15,91	97,64	16,35	97,57	16,77	99
13,92	98,97	14,35	98.90	14,78	98,84	15,21	98,77	15,64	98,70	16,07	98,63	16,52	98,56	16,94	100
14,06	99,96	14,49	99,89	14,93	99,83	15,36	99,76	15,80	99,69	16,24	99,62	16,68	99,55	17,11	101
14,20	100,9	14,64	100,9	15,08	100,8	15,52	100,7	15,96	100,7	16,40	100,6	16,85	100,5	17,27	102
14,33	101,9	14,78	101,9	15,22	101,8	15,67	101,7	16,11	101,7	16,56	101,6	17,01	101,5	17,44	103
14,47	102,9	14,92	102,9	15,37	102,8	15,82	102,7	16,27	102,6	16,72	102,6	17,18	102,5	17,61	104
14,61	103,9	15,07	103,8	15,52	103,8	15,97	103,7	16,43	103,6	16,88	103,6	17,34	103,5	17,78	105
14,75	104,9	15,21	104,8	15,67	104,8	16,12	104,7	16,58	104,6	17,04	104,6	17,51	104,5	17,95	106
14,89	105,9	15,35	105,8	15,82	105,8	16,28	105,7	16,74	105,6	17,20	105,5	17,67	105,5	18,12	107
15,03	106,9	15,50	106,8	15,96	106,7	16,43	106,7	16,90	106,6	17,36	106,5	17,84	106,4	18,29	108
15,17	107,9	15,64	107,8	16,11	107,7	16,58	107,7	17,05	107,6	17,52	107,5	18,00	107,4	18,46	109
15,31	108,9	15,78	108,8	16,26	108,7	16,73	108,6	17,21	108,6	17,68	108,5	18,17	108,4	18,63	110
15,45	109,9	15,93	109,8	16,41	109,7	16,89	109,6	17,36	109,6	17,84	109,5	18,33	109,4	18,80	111
15,59	110,8	16,07	110,8	16,56	110,7	17,04	110,6	17,52	110,5	18,00	110,5	18,50	110,4	18,97	112
15,73	111,8	16,21	111,8	16,70	111,7	17,19	111,6	17,68	111,5	18,16	111,5	18,66	111,4	19,14	113
15,87	112,8	16,36	112,7	16,85	112,7	17,34	112,6	17,83	112,5	18,32	112,4	18,83	112,4	19,31	114
16,01	113,8	16,50	113,7	17,00	113,7	17,49	113,6	17,99	113,5	18,49	113,4	18,99	113,3	19,48	115
16,14	114,8	16,65	114,7	17,15	114,7	17,65	114,6	18,15	114,5	18,65	114,4	19,16	114,3	19,65	116
16,28	115,8	16,79	115,7	17,30	115,6	17,80	115,6	18,30	115,5	18,81	115,4	19,32	115,3	19,81	117
16,42	116,8	16,93	116,7	17,44	116,6	17,95	116,5	18,46	116,5	18,97	116,4	19,49	116,3	19,98	118
16,56	117,8	17,08	117,7	17,59	117,6	18,10	117,5	18,62	117,5	19,13	117,4	19,65	117,3	20,15	119
16,70	118,8	17,22	118,7	17.74	118,6	18,25	118,5	18,77	118,4	19,29	118,4	19,81	118,3	20,31	120
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
Min.	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
Deg.	81 Degrees								80 Degrees						

Distance	10 Degrees								11 Degrees						
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 M
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
1	1,00	0,17	0,98	0,18	0,98	0,18	0,98	0,19	0,98	0,19	0,98	0,20	0,98	0,20	0,98
2	1,97	0,35	1,97	0,36	1,97	0,36	1,97	0,37	1,96	0,38	1,96	0,39	1,96	0,40	1,96
3	2,95	0,52	2,95	0,53	2,95	0,55	2,95	0,56	2,95	0,57	2,94	0,59	2,94	0,60	2,94
4	3,94	0,70	3,94	0,71	3,93	0,73	3,93	0,75	3,93	0,76	3,92	0,78	3,92	0,80	3,92
5	4,92	0,87	4,92	0,89	4,92	0,91	4,91	0,93	4,91	0,95	4,90	0,98	4,90	1,00	4,90
6	5,91	1,04	5,90	1,07	5,90	1,09	5,90	1,12	5,89	1,15	5,89	1,17	5,88	1,20	5,87
7	6,89	1,22	6,89	1,25	6,88	1,28	6.88	1,31	6,87	1,34	6,87	1,37	6,86	1,40	6,85
8	7,88	1,39	7,87	1,42	7,87	1,46	7,86	1,49	7,85	1,53	7,85	1,56	7,84	1,60	7,83
9	8,86	1,56	8,86	1,60	8,85	1,64	8,84	1,68	8,84	1,72	8,83	1,76	8,82	1,79	8,81
10	9,85	1,74	9,84	1,78	9,83	1,82	9,83	1,87	9,82	1,91	9,81	1,95	9,80	1,99	9,79
11	10,83	1,91	10,82	1,96	10,82	2,01	10,81	2,05	10,80	2,10	10,79	2,15	10,78	2,19	10,77
12	11,82	2,08	11,81	2,14	11,80	2,19	11,79	2,24	11,78	2,29	11,77	2,34	11,76	2,39	11,75
13	12,80	2,26	12,79	2,31	12,78	2,37	12,77	2,43	12,76	2,48	12,75	2,54	12,74	2,59	12,73
14	13,78	2,43	13,78	2,49	13,77	2,55	13,75	2,61	13,74	2,67	13,73	2,73	13,72	2,79	13,71
15	14,77	2,61	14,76	2,67	14,75	2,73	14,74	2,80	14,73	2,86	14,71	2,93	14,70	2,99	14,69
16	15,76	2,78	15,74	2,85	15,73	2,92	15,72	2,98	15,71	3,05	15,69	3,12	15,68	3,19	15,67
17	16,74	2,95	16,73	3,03	16,72	3,10	16,70	3,17	16,69	3,24	16,67	3,32	16,66	3,39	16,64
18	17,73	3,13	17,71	3,20	17,70	3,28	17,68	3,36	17,67	3,43	17,65	3,51	17,64	3,59	17,62
19	18,71	3,30	18,70	3,38	18,69	3,46	18,67	3,54	18,65	3,63	18,64	3,71	18,62	3,79	18,60
20	19,70	3,47	19,68	3,56	19,67	3,65	19,65	3,73	19,63	3,82	19,62	3,90	19,60	3,99	19,58
21	20,68	3,65	20,67	3,74	20,65	3,83	20,63	3,92	20,62	4,01	20,60	4,10	20,58	4,19	20,56
22	21,67	3,82	21,65	3,92	21,63	4,01	21,61	4,10	21,60	4,20	21,58	4,29	21,56	4,39	21,54
23	22,65	3,99	22,63	4,09	22,61	4,19	22,60	4,29	22,58	4,39	22,56	4,49	22,54	4,59	22,52
24	23,64	4,17	23,62	4,27	23,60	4,37	23,58	4,48	23,56	4,58	23,54	4,68	23,52	4,78	23,50
25	24,62	4,34	24,60	4,45	24,58	4,56	24,56	4,66	24,54	4,77	24,52	4,88	24,50	4,98	24,48
26	25,61	4,51	25,59	4,63	25,56	4,74	25,54	4,85	25,52	4,96	25,50	5,07	25,48	5,18	25,46
27	26,59	4,69	26,57	4,81	26,55	4,92	26,53	5,04	26,50	5,15	26,48	5,27	26,46	5,38	26,43
28	27,57	4,86	27,55	4,98	27,53	5,10	27,51	5,22	27,49	5,34	27,46	5,46	27,44	5,58	27,41
29	28,56	5,04	28,54	5,16	28,51	5,29	28,49	5,41	28,47	5,53	28,44	5,66	28,42	5,78	28,39
30	29,54	5,21	29,52	5,34	29,50	5,47	29,47	5,60	29,45	5,72	29,42	5,85	29,40	5,98	29,37
31	30,53	5,38	30,51	5,52	30,48	5,65	30,46	5,78	30,43	5,92	30,41	6,05	30,38	6,18	30,35
32	31,51	5,56	31,49	5,69	31,46	5,83	31,44	5,97	31,41	6,11	31,39	6,24	31,36	6,38	31,33
33	32,50	5,73	32,47	5,87	32,45	6,01	32,42	6,16	32,39	6,30	32,37	6,44	32,34	6,58	32,31
34	33,48	5,91	33,46	6,05	33,43	6,20	33,40	6,34	33,38	6,49	33,35	6,63	33,32	6,78	33,29
35	34,47	6,08	34,44	6,23	34,41	6,38	34,39	6,53	34,36	6,68	34,33	6,83	34,30	6,98	34,27
36	35,45	6,25	35,43	6,41	35,40	6,56	35,37	6,72	35,34	6,87	35,31	7,02	35,28	7,18	35,25
37	36,44	6,43	36,41	6,58	36,38	6,74	36,35	6,90	36,32	7,06	36,29	7,22	36,26	7,38	36,23
38	37,42	6,60	37,39	6,76	37,36	6,93	37,33	7,09	37,30	7,25	37,27	7,41	37,24	7,58	37,20
39	38,41	6,77	38,38	6,94	38,35	7,11	38,32	7,28	38,28	7,44	38,25	7,61	38,22	7,78	38,18
40	39,39	6,95	39,36	7,12	39,33	7,29	39,30	7,46	39,27	7,63	39,23	7,80	39,20	7,98	39,16
41	40,38	7,12	40,35	7,30	40,31	7,47	40,28	7,65	40,25	7,82	40,21	8,00	40,18	8,17	40,14
42	41,36	7,29	41,33	7,47	41,30	7,65	41,26	7,83	41,23	8,01	41,19	8,19	41,16	8,37	41,12
43	42,35	7,47	42,31	7,65	42,28	7,84	42,25	8,02	42,21	8,20	42,17	8,39	42,14	8,57	42,10
44	43,33	7,64	43,30	7,83	43,26	8,02	43,23	8,21	43,19	8,40	43,16	8,58	43,12	8,77	43,08
45	44,32	7,81	44,28	8,01	44,25	8,20	44,21	8,39	44,17	8,59	44,14	8,78	44,10	8,97	44,06
46	45,30	7,99	45,27	8,19	45,23	8,38	45,19	8,58	45,16	8,78	45,12	8,97	45,08	9,17	45,04
47	46,29	8,16	46,25	8,36	46,21	8,57	46,18	8,77	46,14	8,97	46,10	9,17	46,06	9,37	46,02
48	47,27	8,33	47,23	8,54	47,20	8,7	47,16	8,95	47,12	9,16	47,08	9,37	47,04	9,57	47,00
49	48,26	8,51	48,22	8,72	48,18	8,93	48,14	9,14	48,10	9,35	48,06	9,56	48,02	9,77	47,97
50	49,24	8,68	49,20	8,90	49,16	9,11	49,12	9,33	49,08	9,54	49,04	9,76	49,00	9,97	48,95
51	50,23	8,86	50,19	9,08	50,15	9,29	50,11	9,51	50,06	9,73	50,02	9,95	49,98	10,17	49,93
52	51,21	9,03	51,17	9,25	51,13	9,48	51,09	9,70	51,05	9,92	51,00	10,15	50,96	10,37	50,91
53	52,20	9,20	52,15	9,43	52,11	9,66	52,07	9,89	52,03	10,11	51,98	10,34	51,94	10,57	51,89
54	53,18	9,38	53,14	9,61	53,10	9,84	53,05	10,07	53,01	10,30	52,96	10,54	52,92	1,077	52,87
55	54,17	9,55	54,12	9,79	54,08	10,02	54,04	10,26	53,99	10,50	53,94	10,73	53,90	10,97	53,85
56	55,15	9,75	55,11	9,97	55,06	10,21	55,02	10,45	54,97	10,69	54,93	10,93	54,88	11,17	54,83
57	56,14	9,90	56,09	10,14	56,05	10,39	56,00	10,63	55,95	10,88	55,91	11,12	55,86	11,37	55,81
58	57,12	10,07	57,07	10,32	57,03	10,57	56,98	10,82	56,94	11,07	56,89	11,32	56,84	11,56	56,79
59	58,10	10,25	58,06	10,50	58,01	10,75	57,97	11,01	57,92	11,26	57,87	11,51	57,82	11,76	57,76
60	59,09	10,42	59,04	10,68	59,99	10,93	58,95	11,19	58,90	11,45	58,85	11,71	58,80	11,96	58,74
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 M:
	80 Deg.		79 Degrees								78 Degrees				

10 Degrees								11 Degrees								Distance
Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
t.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
07	10,59	60,03	10,85	59,98	11,12	59,93	11,38	58,93	11,64	59,83	11,90	59,78	12,16	59,72	12,41	61
06	10,77	61,01	11,03	60,96	11,30	60,91	11,56	60,86	11,83	60,81	12,09	60,76	12,36	60,70	12,63	62
04	10,94	61,99	11,21	61,94	11,48	61,89	11,75	61,84	12,02	61,79	12,29	61,74	12,56	61,68	12,83	63
03	11,11	62,98	11,39	62,93	11,66	62,88	11,94	62,83	12,21	62,77	12,49	62,72	12,76	62,66	13,03	64
01	11,29	63,96	11,57	63,91	11,85	63,86	12,12	63,81	12,40	63,75	12,68	63,70	12,96	63,64	13,21	65
00	11,46	64,95	11,74	64,89	12,03	64,84	12,31	64,79	12,59	64,73	12,88	64,68	13,16	64,62	13,44	66
8	11,64	65,93	11,92	65,88	12,21	65,82	12,50	65,77	12,79	65,71	13,07	65,66	13,36	65,60	13,64	67
7	11,81	66,91	12,10	66,86	12,39	66,81	12,68	66,75	12,98	66,59	13,27	66,64	13,56	66,58	13,85	68
5	11,98	67,90	12,28	67,84	12,57	67,79	12,87	67,73	13,17	67,67	13,46	67,61	13,76	67,55	14,05	69
4	12,16	68,88	12,46	68,83	12,76	68,77	13,06	68,71	13,36	68,66	13,66	68,59	13,96	68,53	14,26	70
2	12,38	69,87	12,63	69,81	12,94	69,75	13,24	69,70	13,55	69,64	13,85	69,57	14,16	69,51	14,46	71
1	12,50	70,85	12,81	70,79	13,12	70,74	13,43	70,68	13,74	70,62	14,05	70,55	14,36	70,49	14,66	72
9	12,68	71,84	12,99	71,73	13,30	71,72	13,61	71,66	13,93	71,60	14,24	71,53	14,55	71,47	14,87	73
8	12,85	72,82	13,17	72,76	13,49	72,70	13,80	72,64	14,12	72,58	14,44	72,51	14,75	72,45	15,07	74
6	13,02	73,80	13,35	73,74	13,67	73,68	13,99	73,62	14,31	73,56	14,63	73,49	14,95	73,43	15,27	75
5	13,20	74,79	13,52	74,73	13,85	74,67	14,18	74,60	14,50	74,54	14,83	74,47	15,15	74,41	15,48	76
3	13,37	75,77	13,70	75,71	14,03	75,65	14,36	75,59	14,69	75,52	15,02	75,45	15,35	75,39	15,68	77
2	13,54	76,76	13,88	76,69	14,22	76,63	14,55	76,57	14,88	76,50	15,22	76,43	15,55	76,37	15,88	78
0	13,72	77,74	14,06	77,68	14,40	77,61	14,74	77,55	15,07	77,48	15,41	77,41	15,75	77,35	16,09	79
9	13,89	78,72	14,24	78,66	14,58	78,60	14,92	78,53	15,27	78,46	15,61	78,39	15,95	78,32	16,29	80
7	14,07	79,71	14,41	79,64	14,76	79,58	15,11	79,51	15,46	79,44	15,80	79,37	16,15	79,30	16,50	81
6	14,24	80,69	14,59	80,63	14,94	80,56	15,30	80,49	15,65	80,43	16,00	80,35	16,35	80,28	16,70	82
4	14,41	81,68	14,77	81,61	15,13	81,54	15,48	81,48	15,84	81,41	16,19	81,33	16,55	81,26	16,90	83
2	14,59	82,66	14,95	82,59	15,31	82,53	15,67	82,46	16,03	82,39	16,39	82,31	16,75	82,24	17,11	84
3	14,76	83,64	15,13	83,58	15,49	83,51	15,86	83,44	16,22	83,37	16,58	83,29	16,95	83,22	17,31	85
1	14,93	84,63	15,30	84,56	15,67	84,49	16,04	84,42	16,41	84,35	16,78	84,27	17,15	84,20	17,51	86
0	15,11	85,61	15,48	85,54	15,85	85,47	16,23	85,40	16,60	85,33	16,97	85,25	17,35	85,18	17,72	87
8	15,28	86,60	15,66	86,53	16,04	86,46	16,41	86,38	16,79	86,31	17,17	86,23	17,55	86,16	17,92	88
7	15,46	87,58	15,84	87,51	16,22	87,44	16,60	87,37	16,98	87,29	17,36	87,21	17,74	87,14	18,12	89
5	15,62	88,56	16,02	88,49	16,40	88,42	16,79	88,35	17,17	88,27	17,56	88,19	17,94	88,12	18,38	90
2	15,80	89,55	16,19	89,48	16,53	89,40	16,97	89,33	17,36	89,25	17,75	89,17	18,14	89,09	18,53	91
0	15,98	90,53	16,37	90,46	16,77	90,39	17,16	90,31	17,56	90,23	17,95	90,15	18,34	90,07	18,74	92
9	16,15	91,52	16,55	91,44	16,95	91,37	17,35	91,29	17,75	91,21	18,14	91,13	18,54	91,05	18,94	93
7	16,32	92,50	16,73	92,43	17,13	92,35	17,53	92,27	17,94	92,19	18,34	92,11	18,74	92,03	19,14	94
6	16,50	93,48	16,91	93,41	17,31	93,33	17,72	93,26	18,13	93,18	18,54	93,09	18,94	93,01	19,35	95
4	16,67	94,47	17,08	94,39	17,50	94,32	17,91	94,24	18,32	94,16	18,73	94,07	19,14	93,99	19,55	96
3	16,85	95,45	17,26	95,38	17,68	95,30	18,09	95,22	18,51	95,14	18,92	95,05	19,34	94,97	19,75	97
1	17,02	96,44	17,44	96,36	17,86	96,28	18,28	96,20	18,70	96,12	19,12	96,03	19,54	95,95	19,96	98
0	17,19	97,42	17,62	97,34	18,04	97,26	18,47	97,18	18,89	97,10	19,31	97,01	19,74	96,93	20,16	99
8	17,37	98,40	17,79	98,33	18,22	98,25	18,65	98,16	19,08	98,08	19,51	97,99	19,94	97,91	20,36	100
7	17,54	99,39	17,97	99,31	18,41	99,23	18,84	99,15	19,27	99,06	19,70	98,97	20,14	98,88	20,57	101
4	17,71	100,4	18,15	100,3	18,59	100,2	19,03	100,1	19,46	100,0	19,90	99,95	20,34	99,86	20,77	102
4	17,89	101,4	18,33	101,3	18,77	101,2	19,21	102,1	19,65	101,0	20,09	100,9	20,54	100,8	20,98	103
4	18,06	102,3	18,51	102,3	18,95	102,2	19,40	103,1	19,84	102,0	20,29	101,9	20,73	101,8	21,18	104
3	18,23	103,3	18,68	103,2	19,14	103,2	19,59	104,0	20,04	103,0	20,48	102,9	20,93	102,8	21,38	105
3	18,41	104,3	18,86	104,2	19,32	104,1	19,77	105,0	20,23	104,0	20,68	103,9	21,13	103,8	21,59	106
3	18,58	105,3	19,04	105,2	19,50	105,1	19,96	106,0	20,42	104,9	20,88	104,8	21,33	104,8	21,79	107
3	18,75	106,3	19,22	106,2	19,68	106,1	20,14	107,0	20,61	105,9	21,07	105,8	21,53	105,7	21,99	108
3	18,93	107,3	19,40	107,2	19,86	107,1	20,33	108,0	20,80	106,9	21,27	106,8	21,73	106,7	22,20	109
3	19,10	108,2	19,57	108,2	20,05	108,1	20,52	109,0	21,00	107,9	21,46	107,8	21,93	107,7	22,40	110
3	19,28	109,2	19,75	109,1	20,23	109,1	20,70	109,9	21,18	108,9	21,66	108,8	22,13	108,7	22,60	111
3	19,45	110,2	19,93	110,1	20,41	110,0	20,89	110,9	21,37	109,8	21,85	109,7	22,33	109,6	22,81	112
3	19,62	111,2	20,11	111,1	20,59	111,0	21,08	111,9	21,56	110,8	22,05	110,7	22,53	110,6	23,01	113
3	19,80	112,2	20,29	112,1	20,78	112,0	21,26	112,9	21,75	111,8	22,24	111,7	22,73	111,6	23,22	114
3	19,97	113,2	20,46	113,1	20,96	113,0	21,45	113,9	21,94	112,8	22,44	112,7	22,93	112,6	23,42	115
2	20,14	114,1	20,64	114,1	21,14	114,0	21,64	114,8	22,13	113,8	22,63	113,7	23,13	113,6	23,62	116
2	20,32	115,1	20,82	115,0	21,32	114,9	21,82	115,8	22,33	114,7	22,83	114,6	23,33	114,5	23,83	117
2	20,49	116,1	21,00	116,0	21,50	115,9	22,01	116,8	22,52	115,7	23,02	115,6	23,53	115,5	24,03	118
2	20,67	117,1	21,18	117,0	21,69	116,9	22,20	117,8	22,71	116,7	23,22	116,6	23,73	116,5	24,23	119
2	20,84	118,1	21,35	118,0	21,87	117,9	22,38	118,8	22,90	117,7	23,41	117,6	23,92	117,5	24,44	120
D.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
8 Deg.		79 Degrees								78 Degrees						

Diſtance	12 Degrees								13 Degrees						
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
1	0,98	0,21	0,98	0,21	0,98	0,22	0,98	0,21	0,97	0,23	0,97	0,23	0,97	0,23	0,97
2	1,96	0,42	1,95	0,42	1,95	0,43	1,95	0,44	1,95	0,45	1,95	0,46	1,95	0,47	1,94
3	2,93	0,62	2,93	0,64	2,93	0,65	2,93	0,66	2,92	0,68	2,92	0,69	2,92	0,70	2,91
4	3,91	0,83	3,91	0,85	3,91	0,87	3,90	0,88	3,90	0,90	3,89	0,92	3,89	0,93	3,89
5	4,89	1,04	4,89	1,06	4,88	1,08	4,88	1,10	4,87	1,13	4,87	1,15	4,86	1,17	4,86
6	5,87	1,25	5,86	1,27	5,86	0,30	5,85	1,32	5,85	1,35	5,84	1,38	5,83	1,40	5,83
7	6,85	1,46	6,84	1,49	6,83	1,52	6,83	1,55	6,82	1,58	6,81	1,60	6,81	1,63	6,80
8	7,83	1,66	7,82	1,70	7,81	1,73	7,80	1,77	7,80	1,80	7,79	1,83	7,78	1,87	7,77
9	8,80	1,87	8,80	1,91	8,79	1,95	8,78	1,99	8,77	2,03	8,76	2,06	8,75	2,10	8,74
10	9,78	2,08	9,77	2,12	9,76	2,16	9,75	2,21	9,74	2,25	9,73	2,29	9,72	2,34	9,71
11	10,76	2,29	10,75	2,33	10,74	2,38	10,73	2,43	10,72	2,47	10,71	2,52	10,70	2,57	10,69
12	11,74	2,50	11,73	2,55	11,72	2,60	11,70	2,65	11,69	2,70	11,68	2,75	11,67	2,80	11,66
13	12,72	2,70	12,71	2,76	12,69	2,81	12,68	2,87	12,67	2,92	12,65	2,98	12,64	3,03	12,63
14	13,70	2,91	13,68	2,97	13,67	3,03	13,66	3,09	13,64	3,15	13,63	3,21	13,61	3,27	13,60
15	14,67	3,12	14,66	3,18	14,65	3,25	14,63	3,31	14,62	3,37	14,60	3,44	14,59	3,50	14,57
16	15,65	3,33	15,64	3,40	15,62	3,46	15,61	3,53	15,59	3,60	15,57	3,67	15,56	3,74	15,54
17	16,63	3,53	16,61	3,61	16,60	3,68	16,58	3,75	16,57	3,82	16,55	3,90	16,53	3,97	16,51
18	17,61	3,74	17,59	3,82	17,57	3,90	17,56	3,97	17,54	4,05	17,52	4,13	17,50	4,20	17,48
19	18,59	3,95	18,57	4,03	18,55	4,11	18,53	4,19	18,51	4,27	18,49	4,36	18,48	4,44	18,46
20	19,56	4,16	19,55	4,24	19,53	4,33	19,51	4,41	19,49	4,50	19,47	4,58	19,45	4,67	19,43
21	20,54	4,37	20,52	4,46	20,50	4,55	20,48	4,64	20,46	4,72	20,44	4,81	20,42	4,90	20,40
22	21,52	4,57	21,50	4,67	21,48	4,76	21,46	4,86	21,44	4,95	21,42	5,04	21,39	5,14	21,37
23	22,50	4,78	22,48	4,88	22,46	4,98	22,43	5,08	22,41	5,17	22,39	5,27	22,36	5,37	22,34
24	23,48	4,99	23,45	5,09	23,43	5,20	23,41	5,30	23,38	5,40	23,36	5,50	23,34	5,60	23,31
25	24,45	5,20	24,43	5,31	24,41	5,41	24,39	5,51	24,36	5,62	24,34	5,73	24,31	5,84	24,28
26	25,43	5,41	25,41	5,52	25,38	5,63	25,36	5,74	25,33	5,85	25,31	5,96	25,28	6,07	25,26
27	26,41	5,61	26,39	5,73	26,36	5,85	26,34	5,96	26,31	6,07	26,28	6,19	26,25	6,30	26,23
28	27,39	5,82	27,36	5,94	27,34	6,06	27,31	6,18	27,28	6,30	27,26	6,42	27,23	6,54	27,20
29	28,37	6,03	28,34	6,15	28,31	6,28	28,29	6,40	28,26	6,52	28,23	6,65	28,20	6,77	28,17
30	29,35	6,24	29,32	6,37	29,29	6,49	29,26	6,62	29,23	6,75	29,20	6,88	29,17	7,00	29,14
31	30,32	6,45	30,29	6,58	30,27	6,71	30,24	6,84	30,21	6,97	30,17	7,11	30,14	7,24	30,11
32	31,30	6,65	31,27	6,79	31,24	6,93	31,21	7,06	31,18	7,20	31,15	7,33	31,12	7,47	31,08
33	32,28	6,86	32,25	7,00	32,22	7,14	32,19	7,28	32,15	7,42	32,12	7,56	32,09	7,70	32,05
34	33,26	7,07	33,23	7,21	33,19	7,36	33,16	7,50	33,13	7,65	33,10	7,79	33,06	7,94	33,03
35	34,24	7,28	34,20	7,43	34,17	7,58	34,14	7,73	34,10	7,87	34,07	8,02	34,03	8,17	34,00
36	35,21	7,48	35,18	7,64	35,15	7,79	35,11	7,95	35,08	8,10	35,04	8,25	35,01	8,41	34,97
37	36,19	7,69	36,16	7,85	36,12	8,01	36,09	8,17	36,05	8,32	36,02	8,48	35,98	8,64	35,94
38	37,17	7,90	37,14	8,06	37,10	8,23	37,06	8,39	37,03	8,55	36,99	8,71	36,95	8,87	36,91
39	38,15	8,11	38,11	8,28	38,08	8,44	38,04	8,61	38,00	8,77	37,96	8,94	37,92	9,11	37,88
40	39,13	8,32	39,09	8,48	39,05	8,66	39,01	8,83	38,98	9,00	38,94	9,17	38,90	9,34	38,85
41	40,10	8,52	40,07	8,70	40,03	8,88	39,99	9,05	39,95	9,22	39,91	9,40	39,87	9,57	39,83
42	41,08	8,73	41,04	8,91	41,01	9,09	40,97	9,27	40,92	9,45	40,88	9,63	40,84	9,81	40,80
43	42,06	8,94	42,02	9,12	41,98	9,31	41,94	9,49	41,90	9,67	41,86	9,86	41,81	10,04	41,77
44	43,04	9,15	43,00	9,34	42,96	9,52	42,92	9,71	42,87	9,90	42,83	10,09	42,78	10,27	42,74
45	44,02	9,36	43,98	9,55	43,93	9,74	43,89	9,93	43,85	10,12	43,80	10,31	43,76	10,51	43,71
46	45,00	9,56	44,95	9,76	44,91	9,96	44,87	10,15	44,82	10,35	44,78	10,54	44,73	10,74	44,68
47	45,97	9,77	45,93	9,97	45,89	10,17	45,84	10,37	45,80	10,57	45,75	10,77	45,70	10,97	45,65
48	46,95	9,98	46,91	10,19	46,86	10,39	46,82	10,59	46,77	10,80	46,72	11,00	46,67	11,21	46,63
49	47,93	10,19	47,88	10,40	47,84	10,61	47,79	10,81	47,74	11,02	47,70	11,23	47,65	11,44	47,60
50	48,91	10,40	48,86	10,61	48,82	10,82	48,77	11,04	48,72	11,25	48,67	11,46	48,62	11,67	48,57
51	49,89	10,60	49,84	10,82	49,79	11,04	49,74	11,26	49,69	11,47	49,64	11,69	49,59	11,91	49,54
52	50,86	10,81	50,82	11,03	50,77	11,26	50,72	11,48	50,67	11,70	50,62	11,92	50,56	12,14	50,51
53	51,84	11,02	51,79	11,25	51,74	11,47	51,69	11,70	51,64	11,92	51,59	12,15	51,54	12,37	51,48
54	52,82	11,23	52,77	11,46	52,72	11,69	52,67	11,92	52,62	12,15	52,56	12,38	52,51	12,61	52,45
55	53,80	11,44	53,75	11,67	53,70	11,91	53,65	12,14	53,59	12,37	53,54	12,61	53,48	12,84	53,42
56	54,78	11,64	54,73	11,88	54,67	12,12	54,62	12,36	54,57	12,60	54,51	12,84	54,45	13,07	54,40
57	55,76	11,85	55,70	12,09	55,65	12,34	55,60	12,58	55,54	12,82	55,48	13,06	55,43	13,31	55,37
58	56,73	12,06	56,68	12,31	56,63	12,55	56,57	12,80	56,51	13,05	56,46	13,29	56,40	13,54	56,34
59	57,71	12,27	57,66	12,52	57,60	12,77	57,55	13,02	57,49	13,27	57,43	13,52	57,37	13,77	57,31
60	58,69	12,48	58,63	12,73	58,58	12,99	58,52	13,24	58,46	13,50	58,40	13,75	58,34	14,01	58,28
Diſtance	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15
	78 Deg.		77 Degrees								76 Degrees				

12 Degrees								13 Degrees								Diſtance
o Min.		15 Min.		30 Min.		45 Min.		o Min.		15 Min.		30 Min.		45 Min.		
t.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
67	12,68	59,61	12,94	59,55	13,20	59,50	13,46	59,44	13,72	59,38	13,98	59,31	14,24	59,25	14,50	61
65	12,89	60,59	13,16	60,53	13,42	60,47	13,68	60,41	13,95	60,35	14,21	60,29	14,47	60,22	14,74	62
62	13,10	61,57	13,37	61,51	13,64	61,45	13,90	61,38	14,17	61,32	14,44	61,26	14,71	61,19	14,97	63
60	13,31	62,54	13,58	62,48	13,85	62,42	14,13	62,36	14,40	62,30	14,67	62,23	14,94	62,17	15,21	64
58	13,52	63,52	13,79	63,46	14,07	63,40	14,35	63,33	14,62	63,27	14,90	63,20	15,17	63,14	15,45	65
56	13,72	64,50	14,00	64,44	14,29	64,37	14,57	64,31	14,85	64,24	15,13	64,18	15,41	64,11	15,69	66
54	13,93	65,48	14,22	65,41	14,50	65,35	14,79	65,28	15,07	65,22	15,36	65,15	15,64	65,08	15,93	67
51	14,14	66,45	14,43	66,39	14,72	66,32	15,01	66,26	15,30	66,19	15,59	66,12	15,88	66,05	16,16	68
49	14,35	67,43	14,64	67,37	14,93	67,30	15,23	67,23	15,52	67,16	15,82	67,09	16,11	67,02	16,40	69
47	14,55	68,41	14,85	68,34	15,15	68,27	15,45	68,21	15,75	68,14	16,04	68,07	16,34	67,99	16,64	70
45	14,76	69,38	15,07	69,32	15,37	69,25	15,67	69,18	15,97	69,11	16,27	69,04	16,58	68,97	16,88	71
43	14,97	70,36	15,28	70,29	15,58	70,23	15,89	70,15	16,20	70,08	16,50	70,01	16,81	69,94	17,11	72
41	15,18	71,34	15,49	71,27	15,80	71,20	16,11	71,13	16,42	71,06	16,73	70,98	17,04	70,91	17,35	73
38	15,39	72,32	15,70	72,25	16,02	72,18	16,33	72,10	16,65	72,03	16,96	71,96	17,28	71,88	17,59	74
36	15,59	73,29	15,91	73,22	16,23	73,15	16,55	73,08	16,87	73,00	17,19	72,93	17,51	72,85	17,82	75
34	15,80	74,27	16,13	74,20	16,45	74,13	16,77	74,05	17,10	73,98	17,42	73,90	17,74	73,82	18,06	76
32	16,01	75,25	16,34	75,18	16,67	75,10	16,99	75,03	17,32	74,95	17,65	74,87	17,98	74,79	18,30	77
30	16,22	76,22	16,55	76,16	16,88	76,08	17,22	76,00	17,55	75,92	17,88	75,85	18,21	75,77	18,54	78
27	16,43	77,20	16,76	77,13	17,10	77,05	17,44	76,97	17,77	76,90	18,11	76,82	18,44	76,74	18,78	79
25	16,63	78,18	16,97	78,10	17,32	78,03	17,66	77,95	18,00	77,87	18,34	77,79	18,68	77,71	19,02	80
23	16,84	79,16	17,19	79,08	17,53	79,00	17,88	78,92	18,22	78,84	18,57	78,76	18,91	78,68	19,25	81
21	17,05	80,13	17,40	80,06	17,75	79,98	18,10	79,90	18,45	79,82	18,79	79,74	19,14	79,65	19,49	82
19	17,26	81,11	17,61	81,03	17,97	80,95	18,32	80,87	18,67	80,79	19,02	80,71	19,38	80,62	19,73	83
16	17,47	82,09	17,82	82,01	18,18	81,93	18,54	81,85	18,90	81,76	19,25	81,68	19,61	81,59	19,97	84
14	17,67	83,06	18,04	82,99	18,40	82,91	18,76	82,82	19,12	82,74	19,48	82,65	19,84	82,56	20,20	85
12	17,88	84,04	18,25	83,96	18,61	83,88	18,98	83,80	19,35	83,71	19,71	83,62	20,08	83,54	20,44	86
10	18,09	85,02	18,46	84,94	18,83	84,86	19,20	84,77	19,57	84,68	19,94	84,60	20,31	84,51	20,68	87
08	18,30	86,00	18,67	85,92	19,05	85,83	19,42	85,74	19,80	85,66	20,17	85,57	20,54	85,48	20,92	88
06	18,50	86,97	18,84	86,89	19,26	86,81	19,64	86,72	20,02	86,63	20,40	86,54	20,78	86,45	21,15	89
03	18,71	87,95	19,10	87,87	19,48	87,78	19,86	87,69	20,25	87,60	20,63	87,51	21,01	87,42	21,39	90
01	18,92	88,93	19,31	88,84	19,70	88,76	20,08	88,67	20,47	88,58	20,86	88,49	21,24	88,39	21,63	91
99	19,13	89,91	19,52	89,82	19,91	89,73	20,30	89,64	20,69	89,55	21,08	89,46	21,48	89,36	21,87	92
97	19,34	90,88	19,73	90,80	20,13	90,71	20,53	90,62	20,92	90,52	21,32	90,43	21,71	90,34	22,11	93
95	19,55	91,86	19,95	91,77	20,36	91,68	20,75	91,59	21,14	91,50	21,55	91,40	21,95	91,31	22,34	94
93	19,75	92,84	20,16	92,75	20,56	92,66	20,97	92,56	21,37	92,47	21,77	92,38	22,18	92,28	22,58	95
90	19,96	93,81	20,37	93,73	20,78	93,63	21,19	93,54	21,59	93,44	22,00	93,35	22,41	93,25	22,82	96
88	20,17	94,79	20,58	94,70	21,00	94,61	21,41	94,51	21,82	94,42	22,23	94,32	22,65	94,22	23,05	97
86	20,38	95,77	20,79	95,68	21,21	95,59	21,63	95,49	22,04	95,39	22,46	95,29	22,88	95,19	23,29	98
84	20,58	96,75	21,01	96,66	21,43	96,56	21,85	96,46	22,27	96,36	22,69	96,26	23,11	96,16	23,53	99
82	20,79	97,73	21,22	97,63	21,64	97,53	22,07	97,44	22,49	97,34	22,92	97,24	23,35	97,13	23,77	100
79	21,00	98,70	21,43	98,61	21,86	98,51	22,29	98,41	22,72	98,31	23,15	98,21	23,58	98,11	24,01	101
77	21,21	99,68	21,64	99,58	22,08	99,49	22,51	99,39	22,94	99,29	23,38	99,18	23,81	99,08	24,24	102
1,7	21,42	100,7	21,86	100,6	22,29	100,5	22,73	100,4	23,17	100,3	23,61	100,2	24,05	100,0	24,48	103
1,7	21,62	101,6	22,07	101,5	22,51	101,4	22,95	101,3	23,39	101,2	23,84	101,1	24,28	101,0	24,72	104
1,7	21,83	102,6	22,28	102,5	22,73	102,4	23,17	102,3	23,62	102,2	24,07	102,1	24,51	102,0	24,96	105
1,7	22,04	103,6	22,49	103,5	22,94	103,4	23,39	103,3	23,84	103,2	24,30	103,1	24,75	103,0	25,20	106
1,6	22,25	104,6	22,70	104,5	23,16	104,4	23,62	104,3	24,07	104,2	24,52	104,0	24,98	104,9	25,44	107
1,6	22,45	105,5	22,92	105,4	23,38	105,3	23,84	105,2	24,29	105,1	24,75	105,0	25,21	105,9	25,67	108
1,6	22,66	106,5	23,13	106,4	23,59	106,3	24,06	106,2	24,52	106,1	24,98	106,0	25,45	106,9	25,91	109
1,6	22,87	107,5	23,34	107,4	23,81	107,3	24,28	107,2	24,74	107,1	25,21	107,0	25,68	107,8	26,15	110
1,6	23,08	108,5	23,55	108,4	24,03	108,3	24,50	108,2	24,97	108,0	25,44	108,9	25,91	108,8	26,38	111
1,5	23,29	109,4	23,76	109,3	24,24	109,2	24,72	109,1	25,19	109,0	25,67	109,9	26,15	109,8	26,62	112
1,5	23,49	110,4	23,98	110,3	24,46	110,2	24,94	110,1	25,42	110,0	25,90	110,9	26,38	110,8	26,86	113
1,5	23,70	111,4	24,19	111,3	24,67	111,2	25,16	111,1	25,64	111,0	26,13	111,9	26,61	111,7	27,10	114
1,5	23,91	112,4	24,40	112,3	24,89	112,2	25,38	112,1	25,87	111,9	26,36	112,8	26,85	112,7	27,33	115
1,5	24,12	113,4	24,61	113,3	25,11	113,1	25,60	113,0	26,09	112,9	26,59	113,8	27,08	113,7	27,57	116
1,4	24,33	114,3	24,83	114,2	25,32	114,1	25,82	114,0	26,32	113,9	26,82	114,8	27,31	114,6	27,81	117
1,4	24,53	115,3	25,04	115,2	25,54	115,1	26,04	115,0	26,54	114,9	27,05	115,7	27,55	114,6	28,05	118
1,4	24,74	116,3	25,25	116,2	25,76	116,1	26,26	116,0	26,77	115,8	27,27	116,7	27,78	115,6	28,29	119
1,4	24,94	117,3	25,46	117,2	25,97	117,1	26,48	117,9	26,99	116,8	27,50	117,7	28,01	116,6	28,52	120
p.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Diſtance
Min.		45 Min.		30 Min.		15 Min.		o Min.		45 Min.		30 Min.		15 Min.		
Deg.		77 Degrees								76 Degrees						

Distance	14 Degrees								15 Degrees							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep
1	0,97	0,24	0,97	0,25	0,97	0,25	0,97	0,25	0,97	0,26	0,96	0,26	0,96	0,27	0,96	0,2
2	1,94	0,48	1,94	0,49	1,94	0,50	1,93	0,51	1,93	0,52	1,93	0,53	1,93	0,53	1,92	0,5
3	2,91	0,73	2,91	0,74	2,90	0,75	2,90	0,76	2,90	0,78	2,89	0,79	2,89	0,80	2,89	0,8
4	3,88	0,97	3,88	0,98	3,87	1,00	3,87	1,02	3,86	1,03	3,86	1,05	3,85	1,07	3,85	1,0
5	4,85	1,21	4,85	1,23	4,84	1,25	4,83	1,27	4,83	1,29	4,82	1,31	4,82	1,34	4,81	1,3
6	5,82	1,45	5,81	1,48	5,81	1,50	5,80	1,53	5,80	1,55	5,79	1,58	5,78	1,60	5,77	1,6
7	6,79	1,69	6,78	1,72	6,78	1,75	6,77	1,78	6,76	1,81	6,75	1,84	6,74	1,87	6,74	1,9
8	7,76	1,93	7,75	1,97	7,74	2,00	7,74	2,04	7,73	2,07	7,72	2,10	7,71	2,14	7,70	2,1
9	8,73	2,18	8,72	2,21	8,71	2,25	8,70	2,29	8,69	2,33	8,68	2,37	8,67	2,40	8,66	2,4
10	9,70	2,42	9,69	2,46	9,68	2,50	9,67	2,55	9,66	2,59	9,65	2,63	9,64	2,67	9,62	2,
11	10,67	2,66	10,66	2,71	10,65	2,75	10,64	2,80	10,62	2,85	10,61	2,89	10,60	2,94	10,59	2,
12	11,64	2,90	11,63	2,95	11,62	3,00	11,60	3,05	11,59	3,11	11,58	3,16	11,56	3,21	11,55	3,
13	12,61	3,14	12,60	3,20	12,59	3,25	12,57	3,31	12,56	3,36	12,54	3,42	12,53	3,47	12,51	3,
14	13,58	3,39	13,57	3,45	13,55	3,51	13,54	3,56	13,52	3,62	13,51	3,68	13,49	3,74	13,47	3,
15	14,55	3,63	14,54	3,69	14,52	3,76	14,51	3,82	14,49	3,88	14,47	3,94	14,45	4,01	14,44	4,
16	15,52	3,87	15,51	3,94	15,49	4,01	15,47	4,07	15,45	4,14	15,44	4,21	15,42	4,28	15,40	4,
17	16,49	4,11	16,48	4,18	16,46	4,26	16,44	4,33	16,42	4,40	16,40	4,47	16,38	4,54	16,36	4,
18	17,46	4,35	17,45	4,43	17,43	4,51	17,41	4,58	17,39	4,66	17,37	4,75	17,34	4,81	17,32	4,
19	18,44	4,60	18,42	4,68	18,39	4,76	18,37	4,84	18,35	4,91	18,33	5,00	18,31	5,08	18,29	5,
20	19,41	4,84	19,38	4,92	19,36	5,01	19,34	5,09	19,32	5,18	19,30	5,26	19,27	5,34	19,25	5,
21	20,38	5,08	20,35	5,17	20,33	5,26	20,31	5,35	20,28	5,43	20,26	5,52	20,24	5,61	20,21	5,
22	21,35	5,32	21,32	5,41	21,30	5,51	21,27	5,60	21,25	5,69	21,23	5,79	21,20	5,88	21,17	5,
23	22,32	5,56	22,29	5,66	22,27	5,76	22,24	5,86	22,21	5,95	22,19	6,05	22,16	6,15	22,14	6,
24	23,29	5,81	23,26	5,91	23,24	6,01	23,21	6,11	23,18	6,21	23,15	6,31	23,13	6,41	23,10	6,
25	24,26	6,05	24,23	6,15	24,20	6,26	24,17	6,36	24,15	6,47	24,12	6,58	24,09	6,68	24,06	6,
26	25,23	6,29	25,20	6,40	25,17	6,51	25,14	6,62	25,11	6,73	25,08	6,84	25,05	6,95	25,02	7,
27	26,20	6,53	26,17	6,65	26,14	6,76	26,11	6,88	26,08	6,99	26,05	7,10	26,02	7,22	25,99	7,
28	27,17	6,77	27,14	6,89	27,11	7,01	27,08	7,13	27,05	7,25	27,01	7,36	26,98	7,48	26,95	7,
29	28,14	7,01	28,11	7,14	28,08	7,26	28,04	7,38	28,01	7,51	27,98	7,63	27,95	7,75	27,91	7,
30	29,11	7,26	29,08	7,38	29,04	7,51	29,01	7,64	28,98	7,76	28,94	7,89	28,91	8,02	28,87	8,
31	30,08	7,50	30,05	7,63	30,01	7,76	29,98	7,89	29,94	8,02	29,91	8,15	29,87	8,28	29,84	8,
32	31,05	7,74	31,02	7,88	30,98	8,01	30,95	8,15	30,91	8,28	30,87	8,42	30,84	8,55	30,80	8,
33	32,02	7,98	31,99	8,12	31,95	8,26	31,91	8,40	31,88	8,54	31,84	8,68	31,80	8,82	31,76	8,
34	32,99	8,23	32,95	8,37	32,92	8,51	32,88	8,66	32,84	8,80	32,80	8,94	32,76	9,09	32,72	9,
35	33,96	8,47	33,92	8,62	33,89	8,76	33,85	8,91	33,81	9,06	33,77	9,21	33,73	9,35	33,69	9,
36	34,93	8,71	34,89	8,86	34,85	9,01	34,81	9,17	34,77	9,32	34,73	9,47	34,69	9,62	34,65	9,
37	35,90	8,95	35,86	9,11	35,82	9,26	35,78	9,42	35,74	9,58	35,70	9,73	35,65	9,89	35,61	10,
38	36,87	9,19	36,83	9,35	36,79	9,51	36,75	9,67	36,71	9,84	36,66	9,99	36,62	10,15	36,57	10,
39	37,84	9,44	37,80	9,60	37,76	9,76	37,71	9,93	37,67	10,09	37,63	10,26	37,58	10,42	37,54	10,
40	38,81	9,68	38,77	9,85	38,73	10,01	38,68	10,18	38,64	10,35	38,59	10,52	38,54	10,69	38,50	10,
41	39,78	9,92	39,74	10,09	39,69	10,27	39,65	10,44	39,60	10,61	39,56	10,78	39,51	10,96	39,46	11,
42	40,75	10,16	40,71	10,34	40,66	10,52	40,62	10,69	40,57	10,87	40,52	11,05	40,47	11,22	40,42	11,
43	41,72	10,40	41,68	10,58	41,63	10,77	41,58	10,95	41,53	11,13	41,49	11,31	41,44	11,49	41,39	11,
44	42,69	10,64	42,65	10,83	42,60	11,02	42,55	11,20	42,50	11,39	42,45	11,57	42,40	11,76	42,35	11,
45	43,66	10,89	43,62	11,08	43,57	11,27	43,52	11,46	43,47	11,65	43,42	11,84	43,36	12,03	43,31	12,
46	44,63	11,13	44,58	11,32	44,53	11,52	44,48	11,72	44,43	11,91	44,38	12,10	44,33	12,29	44,27	12,
47	45,60	11,37	45,55	11,57	45,50	11,76	45,45	11,96	45,40	12,16	45,35	12,36	45,29	12,56	45,24	12,
48	46,57	11,61	46,52	11,81	46,47	12,02	46,42	12,22	46,36	12,42	46,31	12,62	46,25	12,83	46,20	13,
49	47,54	11,85	47,49	12,06	47,44	12,27	47,38	12,47	47,33	12,68	47,27	12,89	47,22	13,09	47,16	13,
50	48,51	12,10	48,46	12,31	48,41	12,52	48,35	12,73	48,30	12,94	48,24	13,15	48,18	13,36	48,12	13,
51	49,48	12,34	49,43	12,55	49,38	12,77	49,32	12,98	49,26	13,20	49,20	13,41	49,15	13,62	49,09	13,
52	50,46	12,58	50,40	12,80	50,34	13,02	50,29	13,24	50,23	13,46	50,17	13,68	50,11	13,90	50,05	14,
53	51,43	12,82	51,37	13,05	51,31	13,27	51,25	13,49	51,19	13,72	51,13	13,94	51,07	14,16	51,01	14,
54	52,40	13,06	52,34	13,29	52,28	13,52	52,22	13,75	52,16	13,98	52,10	14,20	52,04	14,43	51,97	14,
55	53,37	13,31	53,31	13,54	53,25	13,77	53,19	14,00	53,13	14,23	53,06	14,47	53,00	14,70	52,94	14
56	54,34	13,55	54,28	13,78	54,22	14,02	54,15	14,26	54,09	14,49	54,03	14,73	53,96	14,96	53,90	15,
57	55,31	13,79	55,25	14,03	55,18	14,27	55,12	14,51	55,06	14,75	54,99	14,99	54,93	15,23	54,86	15,
58	56,28	14,03	56,22	14,28	56,15	14,52	56,09	14,77	56,02	15,01	55,96	15,26	55,89	15,50	55,82	15,
59	57,25	14,27	57,19	14,52	57,12	14,77	57,06	15,02	56,99	15,27	56,92	15,52	56,85	15,77	56,79	16,
60	58,21	14,51	58,15	14,77	58,09	15,02	58,02	15,28	57,96	15,53	57,89	15,78	57,82	16,03	57,75	16
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	L
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min	
	76 Deg.		75 Degrees								74 Degrees					

14 Degrees								15 Degrees								Distance
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
at.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
,19	14,76	59,12	15,01	59,06	15,27	58,99	15,53	58,92	15,79	58,85	16,04	58,78	16,30	58,71	16,56	61
,16	15,00	60,09	15,26	60,02	15,52	59,96	15,78	59,89	16,05	59,82	16,31	59,74	16,57	59,67	16,83	62
,13	15,24	61,06	15,51	60,99	15,77	60,92	16,04	60,85	16,30	60,78	16,57	60,71	16,84	60,63	17,10	63
,10	15,48	62,03	15,75	61,96	16,02	61,89	16,29	61,82	16,56	61,75	16,83	61,67	17,10	61,60	17,37	64
,07	15,72	63,00	16,00	62,93	16,27	62,86	16,55	62,79	16,82	62,71	17,10	62,64	17,37	62,56	17,64	65
,04	15,97	63,97	16,25	63,90	16,52	63,82	16,80	63,75	17,08	63,68	17,36	63,60	17,64	63,52	17,91	66
,01	16,21	64,94	16,49	64,87	16,78	64,79	17,06	64,72	17,34	64,64	17,62	64,56	17,90	64,48	18,19	67
,98	16,45	65,91	16,74	65,83	17,03	65,76	17,31	65,68	17,60	65,60	17,89	65,53	18,17	65,45	18,46	68
,95	16,69	66,88	16,98	66,80	17,28	66,73	17,57	66,65	17,86	66,57	18,15	66,49	18,44	66,41	18,73	69
,92	16,93	67,85	17,23	67,77	17,53	67,69	17,82	67,61	18,12	67,53	18,41	67,45	18,71	67,37	19,00	70
,89	17,18	68,82	17,48	68,74	17,78	68,66	18,08	68,58	18,38	68,50	18,67	68,42	18,97	68,33	19,27	71
,86	17,42	69,78	17,72	69,71	18,03	69,63	18,33	69,55	18,63	69,46	18,94	69,38	19,24	69,30	19,54	72
,83	17,66	70,75	17,97	70,67	18,28	70,59	18,59	70,51	18,89	70,43	19,20	70,34	19,51	70,26	19,82	73
,80	17,90	71,72	18,22	71,64	18,53	71,56	18,84	71,48	19,15	71,39	19,46	71,31	19,78	71,22	20,09	74
,77	18,14	72,69	18,46	72,61	18,78	72,53	19,09	72,44	19,41	72,36	19,73	72,27	20,04	72,18	20,36	75
,74	18,39	73,66	18,71	73,58	19,03	73,50	19,35	73,41	19,67	73,32	19,99	73,24	20,31	73,15	20,63	76
,71	18,03	74,63	18,95	74,5	19,28	74,46	19,60	74,38	19,93	74,29	20,25	74,21	20,58	74,11	20,99	77
,68	18,87	75,60	19,20	75,52	19,53	75,43	19,86	75,34	20,19	75,25	20,52	75,16	20,84	75,07	21,17	78
,65	19,11	76,57	19,45	76,48	19,78	76,40	20,11	76,31	20,45	76,22	20,78	76,13	21,11	76,03	21,44	79
,62	19,35	77,54	19,69	77,45	20,03	77,36	20,37	77,27	20,71	77,18	21,04	77,09	21,38	77,00	21,71	80
,59	19,60	78,51	19,94	78,42	20,28	78,33	20,62	78,24	20,96	78,15	21,30	78,05	21,65	77,96	21,99	81
,56	19,84	79,48	20,18	79,39	20,53	79,30	20,88	79,21	21,22	79,11	21,57	79,01	21,91	78,92	22,26	82
,53	20,08	80,45	20,43	80,36	20,78	80,26	21,13	80,17	21,48	80,08	21,83	79,98	22,18	79,88	22,53	83
,50	20,32	81,42	20,68	81,32	21,03	81,23	21,39	81,14	21,74	81,04	22,09	80,94	22,45	80,85	22,80	84
,48	20,56	82,38	20,92	82,29	21,28	82,20	21,64	82,10	22,00	82,01	22,36	81,91	22,71	81,81	23,07	85
,45	20,81	83,35	21,17	83,26	21,53	83,17	21,90	83,07	22,26	82,97	22,62	82,87	22,98	82,77	23,34	86
,42	21,05	84,32	21,41	84,23	21,78	84,13	22,15	84,04	22,52	83,94	22,88	83,83	23,25	83,73	23,61	87
,39	21,29	85,29	21,66	85,20	22,03	85,10	22,40	85,00	22,78	84,90	23,15	84,80	23,52	84,70	23,89	88
,36	21,53	86,26	21,91	86,17	22,28	86,07	22,66	85,97	23,03	85,87	23,41	85,76	23,78	85,66	24,16	89
,33	21,77	87,23	22,15	87,13	22,53	87,03	22,91	86,93	23,29	86,83	23,67	86,73	24,05	86,62	24,43	90
,30	22,01	88,20	22,40	88,10	22,78	88,00	23,17	87,90	23,55	87,80	23,94	87,69	24,32	87,58	24,70	91
,27	22,26	89,17	22,65	89,07	23,03	88,97	23,42	88,87	23,81	88,76	24,20	88,65	24,59	88,55	24,97	92
,24	22,50	90,14	22,89	90,04	23,28	89,94	23,68	89,83	24,07	89,72	24,46	89,62	24,85	89,51	25,24	93
,21	22,74	91,11	23,14	91,01	23,54	90,90	23,93	90,80	24,33	90,69	24,73	90,58	25,12	90,47	25,52	94
,18	22,98	92,08	23,38	91,97	23,79	91,87	24,19	91,76	24,59	91,65	24,99	91,54	25,39	91,48	25,79	95
,15	23,22	93,05	23,63	92,94	24,04	92,84	24,44	92,73	24,85	92,62	25,25	92,51	25,65	92,40	26,06	96
,12	23,47	94,02	23,88	93,91	24,29	93,80	24,70	93,70	25,11	93,58	25,51	93,47	25,92	93,36	26,33	97
,09	23,71	94,98	24,12	94,88	24,54	94,77	24,95	94,66	25,36	94,55	25,78	94,44	26,19	94,32	26,60	98
,06	23,95	95,95	24,37	95,85	24,79	95,74	25,20	95,63	25,62	95,51	26,04	95,40	26,46	95,28	26,87	99
,03	24,19	96,92	24,61	96,81	25,04	96,70	25,46	96,59	25,88	96,48	26,30	96,36	26,72	96,25	27,14	100
,00	24,48	97,89	24,86	97,78	25,29	97,67	25,71	97,56	20,14	97,44	26,57	97,33	26,99	97,21	27,42	101
,97	24,68	98,86	25,11	98,75	25,54	98,64	25,97	98,52	26,40	98,41	26,83	98,29	27,26	98,17	27,69	102
,94	24,92	99,83	25,35	99,71	25,79	99,61	26,22	99,49	26,66	99,37	27,09	99,25	27,53	99,13	27,96	103
0,9	25,16	100,8	25,60	100,7	26,04	100,6	26,48	100,5	26,92	100,3	27,35	100,2	27,79	100,1	28,23	104
1,9	25,40	101,8	25,86	101,7	26,29	101,5	26,73	101,4	27,18	101,3	27,62	101,2	28,06	101,1	28,50	105
2,9	25,64	102,7	26,09	102,6	26,54	102,5	26,99	102,4	27,43	102,3	27,88	102,1	28,33	102,0	28,77	106
3,8	25,88	103,7	26,34	103,6	26,79	103,5	27,24	103,4	27,69	103,2	28,14	103,1	28,59	103,0	29,04	107
4,8	26,13	104,7	26,58	104,6	27,04	104,4	27,50	104,3	27,95	104,2	28,41	104,1	28,86	103,9	29,32	108
5,8	26,37	105,6	26,83	105,6	27,29	105,4	27,75	105,3	28,21	105,2	28,67	105,0	29,13	104,9	29,59	109
6,7	26,61	106,6	27,08	106,5	27,54	106,4	28,01	106,3	28,47	106,1	28,93	106,0	29,40	105,9	29,86	110
7,7	26,85	107,6	27,32	107,5	27,79	107,3	28,26	107,2	28,73	107,1	29,20	107,0	29,66	106,8	30,13	111
8,7	27,09	108,6	27,5	108,4	28,04	108,3	28,51	108,2	28,99	108,1	29,46	107,9	29,93	107,8	30,40	112
9,6	27,34	109,5	27,81	109,4	28,29	109,3	28,77	109,2	29,24	109,0	29,72	108,9	30,20	108,8	30,67	113
0,6	27,58	110,5	28,06	110,4	28,54	110,2	29,02	110,1	29,50	110,0	29,98	109,9	30,46	109,7	30,94	114
1,6	27,82	111,5	28,31	111,3	28,79	111,2	29,28	111,1	29,76	111,0	30,24	110,8	30,73	110,7	31,21	115
2,6	28,06	112,4	28,5	112,3	29,04	112,2	29,53	112,0	30,02	112,9	30,51	111,8	31,00	111,6	31,49	116
3,5	28,30	113,4	28,80	113,3	29,29	113,1	29,79	113,0	30,28	113,9	30,77	112,7	31,27	112,6	31,76	117
4,5	28,55	114,4	29,0	114,2	29,54	114,1	30,04	114,0	30,54	114,8	31,04	113,7	31,53	113,6	32,03	118
5,5	28,79	115,3	29,29	115,2	29,79	115,1	30,38	115,9	30,80	115,8	31,30	114,7	31,80	114,5	32,30	119
6,4	29,0	116,3	29,53	116,2	30,05	116,0	30,55	116,9	31,06	116,8	31,56	115,6	32,07	115,5	32,57	120
ep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
6 Deg.		75 Degrees								74 Degrees						

Diſtance	16 Degrees								17 Degrees							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	De
1	0,96	0,28	0,96	0,28	0,96	0,28	0,96	0,29	0,96	0,29	0,96	0,3	0,95	0,30	0,95	0,
2	1,92	0,51	1,92	0,56	1,92	0,57	1,92	0,58	1,91	0,59	1,91	0,59	1,91	0,60	1,91	0,
3	2,88	0,83	2,88	0,84	2,88	0,85	2,87	0,8	2,87	0,88	2,87	0,89	2,86	0,90	2,86	0,
4	3,84	1,10	3,84	1,12	3,84	1,14	3,83	1,15	3,83	1,17	3,82	1,19	3,82	1,20	3,81	1,
5	4,80	1,38	4,80	1,40	4,79	1,42	4,79	1,44	4,77	1,46	4,78	1,48	4,77	1,50	4,76	1,
6	5,77	1,65	5,76	1,68	5,75	1,70	5,7	1,73	5,74	1,75	5,73	1,78	5,72	1,80	5,71	1,
7	6,73	1,93	6,72	1,96	6,71	1,99	6,70	2,02	6,69	2,05	6,69	2,08	6,68	2,11	6,67	2,
8	7,69	2,21	7,68	2,24	7,67	2,27	7,66	2,31	7,65	2,34	7,64	2,37	7,63	2,41	7,62	2,
9	8,65	2,48	8,64	2,52	8,63	2,56	8,62	2,59	8,61	2,63	8,60	2,67	8,58	2,71	8,57	2,
10	9,61	2,76	9,60	2,80	9,59	2,84	9,58	2,86	9,56	2,92	9,55	2,97	9,54	3,01	9,52	3,
11	10,57	3,03	10,56	3,08	10,55	3,12	10,53	3,17	10,52	3,22	10,51	3,26	10,49	3,31	10,48	3,
12	11,54	3,31	11,52	3,36	11,51	3,41	11,49	3,46	11,48	3,51	11,46	3,56	11,45	3,61	11,43	3,
13	12,50	3,58	12,48	3,64	12,46	3,69	12,45	3,75	12,43	3,81	12,42	3,86	12,40	3,91	12,38	3,
14	13,46	3,86	13,44	3,92	13,42	3,98	13,41	4,04	13,39	4,09	13,37	4,15	13,35	4,21	13,33	4,
15	14,42	4,13	14,40	4,20	14,38	4,26	14,36	4,33	14,35	4,39	14,33	4,45	14,31	4,51	14,29	4,
16	15,38	4,41	15,36	4,48	15,34	4,54	15,32	4,61	15,30	4,68	15,28	4,74	15,26	4,81	15,24	4,
17	16,34	4,69	16,32	4,76	16,30	4,83	16,28	4,90	16,26	4,97	16,24	5,04	16,21	5,11	16,19	5,
18	17,30	4,96	17,28	5,04	17,26	5,11	17,23	5,19	17,21	5,26	17,19	5,34	17,17	5,41	17,14	5,
19	18,26	5,24	18,24	5,32	18,22	5,40	18,19	5,48	18,17	5,56	18,15	5,63	18,12	5,71	18,10	5,
20	19,23	5,51	19,20	5,60	19,18	5,68	19,15	5,76	19,13	5,85	19,10	5,93	19,07	6,01	19,05	6,
21	20,19	5,79	20,16	5,88	20,14	5,96	20,11	6,05	20,08	6,14	20,06	6,23	20,03	6,31	20,00	6,
22	21,15	6,06	21,12	6,16	21,09	6,25	21,07	6,34	21,04	6,43	21,01	6,52	20,98	6,02	20,95	6,
23	22,11	6,34	22,08	6,44	22,05	6,53	22,02	6,63	22,00	6,72	21,97	6,82	21,94	6,92	21,91	7,
24	23,07	6,62	23,04	6,72	23,01	6,82	22,98	6,92	22,95	7,02	22,92	7,12	22,89	7,22	22,86	7,
25	24,03	6,89	24,00	7,0	23,97	7,10	23,94	7,21	23,91	7,31	23,88	7,41	23,84	7,52	23,81	7,
26	24,99	7,17	24,96	7,28	24,93	7,38	24,90	7,49	24,86	7,60	24,83	7,7	24,80	7,82	24,76	7,
27	25,95	7,44	25,92	7,56	25,89	7,67	25,85	7,78	25,82	7,89	25,79	8,01	25,75	8,12	25,72	8,
28	26,91	7,72	26,88	7,84	26,85	7,95	26,81	8,07	26,78	8,19	26,74	8,30	26,70	8,42	26,67	8,
29	27,88	7,99	27,84	8,12	27,81	8,24	37,77	8,36	27,73	8,48	27,70	8,60	27,66	8,72	27,62	8,
30	28,84	8,27	28,80	8,40	28,77	8,52	28,73	8,65	28,69	8,77	28,65	8,90	28,61	9,02	28,57	9,
31	29,80	8,55	29,76	8,68	29,72	8,81	29,68	8,93	29,65	9,06	29,61	9,19	29,57	9,32	29,52	9,
32	30,76	8,82	30,72	8,96	30,69	9,09	30,64	9,22	30,60	9,36	30,56	9,49	30,52	9,62	30,48	9,
33	31,72	9,10	31,68	9,23	31,64	9,37	31,60	9,51	31,56	9,65	31,52	9,79	31,47	9,92	31,43	10,
34	32,68	9,37	32,64	9,51	32,60	9,66	32,56	9,80	32,51	9,94	32,47	10,08	32,42	10,22	32,38	10,
35	33,64	9,65	33,60	9,79	33,56	9,94	33,51	10,09	33,47	10,23	33,43	10,38	33,38	10,53	33,33	10,
36	34,61	9,92	34,56	10,07	34,52	10,23	34,47	10,38	34,43	10,53	34,38	10,68	34,33	10,83	34,29	10,
37	35,57	10,20	35,52	10,35	35,48	10,51	35,43	10,66	35,38	10,82	35,34	10,97	35,29	11,13	35,24	11,
38	36,53	10,47	36,48	10,63	36,44	10,79	36,39	10,95	36,34	11,11	36,29	11,27	36,24	11,43	36,19	11,
39	37,49	10,75	37,44	10,91	37,39	11,08	37,35	11,24	37,30	11,40	37,25	11,56	37,20	11,73	37,14	11,
40	38,45	11,03	38,40	11,19	38,35	11,36	38,30	11,53	38,25	11,7	38,20	11,86	38,15	12,03	38,10	12,
41	39,41	11,30	39,36	11,47	39,31	11,65	39,26	11,82	39,21	11,99	39,16	12,16	39,10	12,33	39,05	12,
42	40,37	11,58	40,32	11,75	40,27	11,93	40,22	12,10	40,17	12,28	40,11	12,46	40,06	12,63	40,00	12,
43	41,33	11,85	41,28	12,03	41,23	12,21	41,18	12,40	41,12	12,57	41,07	12,75	41,01	12,93	40,95	13,
44	42,30	12,13	42,24	12,31	42,19	12,50	42,13	12,68	42,08	12,86	42,02	13,05	41,96	13,23	41,91	13,
45	43,26	12,40	43,20	12,59	43,15	12,78	43,09	12,97	43,03	13,15	42,98	13,34	42,92	13,53	42,86	13,
46	44,22	12,68	44,16	12,87	44,11	13,07	44,05	13,26	43,99	13,4	43,93	13,64	43,87	13,83	43,81	14,
47	45,18	12,96	45,12	13,15	45,07	13,35	45,01	13,55	44,9	13,74	44,89	13,94	44,83	14,13	44,76	14,
48	46,14	13,23	46,08	13,43	46,02	13,63	45,96	13,83	45,90	14, 3	45,84	14,23	45,78	14,43	45,72	14,
49	47,10	13,51	47,04	13,71	46,98	13,92	46,92	14,12	46,86	14,33	46,80	14,53	46, 3	14,74	46,67	14,
50	48,06	13,78	48,00	13,99	47,94	14,20	47,88	14,41	47,82	14,62	47,75	14,83	47,69	15,04	47,62	15,
51	49,02	14,06	48,96	14,27	48,90	14,49	48,84	14,70	48,77	14,91	48,71	15,12	48,64	15,34	48,57	15,
52	49,99	14,33	49,92	14,55	49,86	14,78	49,79	14,98	49,73	15,20	49,66	15,42	49,59	15,64	49,53	15,
53	50,95	14,61	50,88	14,83	50,82	15,05	50,75	15,28	50,68	15,50	50,62	15,72	50,55	15,94	50,48	16,
54	51,91	14,89	51,84	15,11	51,78	15,34	51,71	15,56	51,64	15,79	51,57	16,01	51,50	16,24	51,43	16,
55	52,87	15,16	52,80	15,39	52,74	15,62	52,67	15,85	52,60	16,08	52,53	16,31	52,46	16,54	52,38	16,
56	53,83	15,44	53,76	15,67	53,69	15,91	53,62	16,14	53,55	16,37	53,48	16,61	53,41	16,84	53,34	17,
57	54,79	15,71	54,72	15,95	54,65	16,19	54,58	16,43	54,51	16,67	54,44	16,90	54,36	17,14	54,29	17,
58	55,75	15,99	55,68	16,23	55,61	16,47	55,54	16,72	55,47	16,96	55,39	17,20	55,32	17,44	55,24	17,
59	56,71	16,26	56,64	16,51	56,57	16,76	56,50	17,00	56,42	17,25	56,35	17,50	56,27	17,74	56,19	17,
60	57,68	16,54	57,60	16,79	57,53	17,04	57,45	17,29	57,38	17,54	57,30	17,79	57,22	18,04	57,14	18,
Diſtance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	La
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.	
	74 Deg.		73 Degrees								72 Degrees					

	16 Degrees						17 Degrees								Diſtance
Min.	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
16,81	58,56	17,07	58,49	17,33	58,41	17,58	58,33	17,83	58,26	18,09	58,18	18,34	58,10	18,60	61
17,09	59,52	17,35	59,45	17,61	59,37	17,87	59,29	18,13	59,21	18,39	59,13	18,64	59,05	18,90	62
17,36	60,48	17,63	60,41	17,89	60,33	18,16	60,25	18,42	60,17	18,68	60,08	18,95	60,00	19,21	63
17,64	61,44	17,91	61,36	18,18	61,28	18,45	61,20	18,71	61,12	18,98	61,04	19,25	60,95	19,51	64
17,92	62,40	18,19	62,32	18,46	62,24	18,73	62,16	19,00	62,08	19,27	61,99	19,55	61,91	19,82	65
18,19	63,36	18,47	63,28	18,75	63,20	19,02	63,12	19,30	63,03	19,57	62,95	19,85	62,86	20,12	66
18,47	64,32	18,75	64,24	19,03	64,16	19,31	64,07	19,59	63,99	19,87	63,90	20,15	63,81	20,43	67
18,74	65,28	19,03	65,20	19,31	65,11	19,60	65,03	19,88	64,94	20,16	64,85	20,45	64,76	20,73	68
19,02	66,24	19,31	66,16	19,60	66,07	19,89	65,99	20,17	65,90	20,46	65,81	20,75	65,72	21,04	69
19,30	67,20	19,59	67,12	19,88	67,03	20,17	66,94	20,47	66,85	20,76	66,76	21,05	66,69	21,34	70
19,57	68,16	19,87	68,08	20,17	67,99	20,46	67,90	20,76	67,81	21,05	67,71	21,35	67,62	21,65	71
19,85	69,12	20,15	69,04	20,45	68,95	20,75	68,85	21,05	68,76	21,35	68,67	21,65	68,57	21,95	72
20,12	70,08	20,43	69,99	20,73	69,90	21,04	69,81	21,34	69,72	21,65	69,62	21,95	69,53	22,26	73
20,40	71,04	20,71	70,95	21,02	70,86	21,33	70,77	21,64	70,67	21,94	70,58	22,25	70,48	22,56	74
20,67	72,00	20,99	71,91	21,30	71,82	21,62	71,72	21,93	71,63	22,24	71,53	22,55	71,43	22,86	75
20,95	72,96	21,27	72,87	21,59	72,78	21,90	72,68	22,22	72,58	22,54	72,48	22,85	72,38	23,17	76
21,22	73,92	21,55	73,83	21,87	73,73	22,19	73,64	22,51	73,54	22,83	73,44	23,16	73,34	23,48	77
21,50	74,88	21,83	74,79	22,15	74,69	22,48	74,59	22,81	74,49	23,13	74,39	23,46	74,29	23,78	78
21,78	75,84	22,11	75,75	22,44	75,65	22,77	75,55	23,10	75,45	23,43	75,34	23,76	75,24	24,08	79
22,05	76,80	22,39	76,71	22,72	76,61	23,06	76,50	23,39	76,40	23,72	76,30	24,06	76,19	24,39	80
22,33	77,76	22,67	77,67	23,01	77,56	23,34	77,46	23,68	77,36	24,02	77,25	24,36	77,14	24,69	81
22,60	78,72	22,95	78,62	23,29	78,52	23,62	78,42	23,98	78,31	24,32	78,21	24,66	78,10	25,00	82
22,88	79,68	23,23	79,58	23,57	79,48	23,92	79,37	24,27	79,27	24,61	79,16	24,96	79,05	25,30	83
23,15	80,64	23,51	80,54	23,86	80,44	24,21	80,33	24,56	80,22	24,91	80,11	25,26	80,00	25,61	84
23,43	81,60	23,79	81,50	24,14	81,40	24,50	81,29	24,88	81,18	25,21	81,07	25,56	80,95	25,91	85
23,71	82,56	24,07	82,46	24,43	82,35	24,79	82,24	25,14	82,13	25,50	82,02	25,86	81,91	26,22	86
23,98	83,52	24,35	83,42	24,71	83,31	25,07	83,20	25,44	83,09	25,80	82,97	26,16	82,86	26,52	87
24,26	84,48	24,63	84,38	24,99	84,27	25,36	84,15	25,73	84,04	26,10	83,93	26,46	83,81	26,83	88
24,53	85,45	24,91	85,34	25,28	85,22	25,65	85,11	26,02	85,00	26,39	84,88	26,76	84,76	27,13	89
24,81	86,41	25,19	86,29	25,56	86,18	25,94	86,07	26,31	85,95	26,69	85,84	27,06	85,72	27,44	90
25,08	87,37	25,47	87,25	25,85	87,14	26,23	87,02	26,61	86,91	26,99	86,79	27,36	86,67	27,74	91
25,36	88,33	25,75	88,21	26,13	88,10	26,51	87,98	26,90	87,86	27,28	87,74	27,67	87,62	28,05	92
25,64	89,29	26,03	89,17	26,41	89,05	26,80	88,94	27,19	88,82	27,58	88,70	27,97	88,57	28,35	93
25,91	90,25	26,30	90,13	26,70	90,01	27,09	89,89	27,48	89,77	27,88	89,65	28,27	89,53	28,66	94
26,19	91,21	26,58	91,09	26,98	90,97	27,38	90,85	27,76	90,73	28,17	90,60	28,57	90,48	28,96	95
26,46	92,17	26,86	92,05	27,27	91,93	27,67	91,81	28,07	91,68	28,47	91,56	28,87	91,43	29,27	96
26,74	93,13	27,14	93,01	27,55	92,88	27,96	92,76	28,36	92,64	28,76	92,51	29,17	92,38	29,57	97
27,01	94,09	27,42	93,97	27,83	93,84	28,24	93,72	28,65	93,59	29,06	93,47	29,47	9,334	29,88	98
27,29	95,05	27,70	94,92	28,12	94,80	28,53	94,67	28,94	94,55	29,36	94,42	29,77	94,29	30,18	99
27,56	96,01	27,98	95,88	28,40	95,76	28,82	95,63	29,24	95,50	29,65	95,37	30,07	95,24	30,49	100
27,84	96,97	28,26	96,84	28,69	96,72	29,10	96,59	29,53	96,46	29,95	96,33	30,37	96,19	30,79	101
28,12	97,93	28,54	97,80	28,97	97,67	29,40	97,54	29,82	97,41	30,25	97,28	30,67	97,15	31,10	102
28,39	98,89	28,82	98,76	29,25	98,63	29,69	98,50	30,11	98,37	30,54	98,23	30,97	98,10	31,40	103
28,67	99,85	29,10	99,72	29,54	99,59	29,97	99,46	30,41	99,32	30,84	99,19	31,27	99,05	31,71	104
28,94	100,8	29,38	100,7	29,82	100,5	30,26	100,4	30,70	100,3	31,14	100,1	31,58	100,0	32,01	105
29,22	101,8	29,66	101,6	30,11	101,5	30,55	101,4	30,99	101,2	31,43	101,1	31,88	100,0	32,32	106
29,49	102,7	29,94	102,6	30,39	102,5	30,84	102,3	31,28	102,2	31,73	102,0	32,18	101,9	32,62	107
29,77	103,7	30,22	103,6	30,67	103,4	31,13	103,3	31,58	103,1	32,03	103,0	32,48	102,9	32,93	108
30,05	104,6	30,51	104,5	30,96	104,4	31,41	104,2	31,87	104,1	32,32	104,0	32,78	103,8	33,23	109
30,32	105,6	30,78	105,5	31,24	105,3	31,70	105,2	32,16	105,1	32,62	104,9	33,08	104,8	33,54	110
30,60	106,6	31,06	106,4	31,53	106,3	31,99	106,1	32,45	106,0	32,92	105,9	33,38	105,7	33,84	111
30,87	107,5	31,34	107,4	31,81	107,2	32,28	107,1	32,75	107,0	33,21	106,8	33,68	106,7	34,14	112
31,15	108,5	31,62	108,3	32,09	108,2	32,57	108,1	33,04	108,9	33,51	107,8	33,98	107,6	34,45	113
31,43	109,4	31,90	109,3	32,38	109,2	32,86	109,0	33,33	109,9	33,81	108,7	34,28	108,6	34,75	114
31,70	110,4	32,18	110,3	32,66	110,1	33,14	110,0	33,62	110,8	34,10	109,7	34,58	109,5	35,06	115
31,97	111,4	32,46	111,2	32,95	111,1	33,43	111,9	33,92	111,8	34,40	110,6	34,88	110,5	35,36	116
32,25	112,3	32,74	112,2	33,23	112,0	33,72	112,9	34,21	112,7	34,69	111,6	35,18	111,4	35,67	117
32,53	113,3	33,02	113,1	33,51	113,0	34,01	113,8	34,50	113,7	34,99	112,5	35,48	112,4	35,97	118
32,80	114,2	33,30	114,1	33,80	114,0	34,30	114,8	34,79	114,6	35,29	113,5	35,79	113,3	36,28	119
33,08	115,2	33,58	115,1	34,08	115,9	34,58	115,8	35,08	115,6	35,59	114,4	36,09	114,3	39,58	120
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Diſtance
Min.	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
7 Deg	73 Degrees								72 Degrees						

Distance	18 Degrees								19 Degrees						
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 M
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
1	0,95	0,31	0,95	0,31	0,95	0,32	0,95	0,32	0,95	0,33	0,94	0,33	0,94	0,33	0,94
2	1,90	0,62	1,90	0,63	1,90	0,63	1,89	0,64	1,89	0,65	1,89	0,66	1,88	0,67	1,88
3	2,85	0,93	2,85	0,94	2,84	0,95	2,84	0,96	2,84	0,98	2,83	0,99	2,83	1,00	2,82
4	3,80	1,24	3,80	1,25	3,79	1,27	3,79	1,29	3,78	1,30	3,78	1,32	3,77	1,33	3,76
5	4,75	1,54	4,75	1,57	4,74	1,59	4,73	1,61	4,73	1,63	4,72	1,65	4,71	1,67	4,71
6	5,71	1,85	5,70	1,88	5,69	1,90	5,68	1,93	5,67	1,95	5,66	1,98	5,66	2,00	5,65
7	6,66	2,16	6,65	2,19	6,64	2,22	6,63	2,25	6,62	2,28	6,61	2,31	6,60	2,34	6,59
8	7,61	2,47	7,60	2,50	7,59	2,54	7,57	2,57	7,56	2,60	7,55	2,64	7,54	2,67	7,53
9	8,56	2,78	8,55	2,82	8,53	2,86	8,52	2,89	8,51	2,93	8,50	2,97	8,48	3,00	8,47
10	9,51	3,09	9,50	3,13	9,48	3,17	9,47	3,21	9,46	3,26	9,44	3,30	9,43	3,34	9,41
11	10,46	3,40	10,45	3,44	10,43	3,49	10,42	3,54	10,40	3,58	10,38	3,63	10,37	3,67	10,35
12	11,41	3,71	11,40	3,76	11,38	3,81	11,36	3,86	11,35	3,91	11,33	3,96	11,31	4,01	11,29
13	12,36	4,02	12,35	4,07	12,33	4,12	12,31	4,18	12,29	4,23	12,27	4,29	12,25	4,34	12,24
14	13,31	4,33	13,30	4,38	13,28	4,44	13,26	4,50	13,24	4,56	13,22	4,62	13,20	4,67	13,18
15	14,27	4,63	14,24	4,70	14,22	4,76	14,20	4,82	14,18	4,88	14,16	4,95	14,14	5,01	14,12
16	15,22	4,94	15,19	5,01	15,17	5,08	15,15	5,14	15,13	5,21	15,11	5,27	15,08	5,34	15,06
17	16,17	5,25	16,14	5,32	16,12	5,39	16,10	5,46	16,07	5,53	16,05	5,60	16,02	5,67	16,00
18	17,12	5,56	17,09	5,64	17,07	5,71	17,04	5,79	17,02	5,86	16,99	5,93	16,97	6,01	16,94
19	18,07	5,87	18,04	5,95	18,02	6,03	17,99	6,11	17,97	6,19	17,94	6,26	17,91	6,34	17,88
20	19,02	6,18	18,99	6,26	18,97	6,34	18,94	6,43	18,91	6,51	18,88	6,59	18,85	6,68	18,82
21	19,97	6,49	19,94	6,58	19,91	6,66	19,89	6,71	19,86	6,84	19,83	6,92	19,80	7,01	19,76
22	20,92	6,80	20,89	6,89	20,86	6,98	20,83	7,07	20,80	7,16	20,77	7,25	20,74	7,34	20,71
23	21,87	7,11	21,84	7,20	21,81	7,30	21,78	7,39	21,75	7,49	21,71	7,58	21,68	7,68	21,65
24	22,82	7,42	22,79	7,52	22,76	7,61	22,73	7,71	22,69	7,81	22,66	7,91	22,62	8,01	22,59
25	23,78	7,72	23,74	7,83	23,71	7,93	23,67	8,04	23,64	8,14	23,60	8,24	23,57	8,34	23,53
26	24,73	8,03	24,69	8,14	24,66	8,25	24,62	8,36	24,58	8,46	24,55	8,57	24,51	8,68	24,47
27	25,68	8,34	25,64	8,45	25,60	8,57	25,57	8,68	25,53	8,79	25,49	8,90	25,45	9,01	25,41
28	26,63	8,65	26,59	8,77	26,55	8,88	26,51	9,00	26,47	9,12	26,43	9,23	26,39	9,35	26,35
29	27,58	8,96	27,54	9,08	27,50	9,20	27,46	9,32	27,42	9,44	27,38	9,56	27,34	9,68	27,29
30	28,53	9,27	28,49	9,39	28,45	9,52	28,41	9,64	28,37	9,77	28,32	9,89	28,28	10,01	28,23
31	29,48	9,58	29,44	9,71	29,40	9,84	29,35	9,96	29,31	10,09	29,27	10,22	29,22	10,35	29,18
32	30,43	9,89	30,39	10,02	30,35	10,15	30,30	10,29	30,26	10,42	30,21	10,55	30,16	10,68	30,12
33	31,38	10,20	31,34	10,33	31,29	10,47	31,25	10,61	31,20	10,74	31,15	10,88	31,11	11,01	31,06
34	32,34	10,51	32,30	10,65	32,24	10,79	32,19	10,93	32,15	11,07	32,10	11,21	32,05	11,35	32,00
35	33,29	10,82	33,25	10,96	33,19	11,11	33,14	11,25	33,09	11,39	33,04	11,54	32,99	11,68	32,94
36	34,24	11,12	34,20	11,27	34,14	11,42	34,09	11,57	34,04	11,72	33,99	11,87	33,93	12,02	33,88
37	35,19	11,43	35,15	11,59	35,09	11,74	35,04	11,89	34,98	12,05	34,93	12,20	34,88	12,35	34,82
38	36,14	11,74	36,10	11,90	36,04	12,06	35,98	12,21	35,93	12,37	35,88	12,53	35,82	12,68	35,76
39	37,09	12,05	37,05	12,21	36,98	12,37	36,93	12,54	36,88	12,70	36,82	12,86	36,76	13,02	36,71
40	38,04	12,36	37,99	12,53	37,93	12,69	37,88	12,86	37,82	13,02	37,76	13,19	37,71	13,35	37,65
41	38,99	12,67	38,94	12,84	38,88	13,01	38,81	13,18	38,77	13,34	38,71	13,52	38,65	13,69	38,59
42	39,94	12,98	39,89	13,15	39,83	13,33	39,77	13,50	39,71	13,67	39,65	13,85	39,59	14,02	39,53
43	40,89	13,29	40,84	13,46	40,78	13,64	40,72	13,82	40,66	14,00	40,60	14,18	40,53	14,35	40,47
44	41,85	13,60	41,79	13,78	41,73	13,96	41,66	14,14	41,60	14,32	41,54	14,51	41,48	14,69	41,41
45	42,80	13,91	42,74	14,09	42,67	14,28	42,61	14,47	42,55	14,65	42,48	14,84	42,42	15,02	42,35
46	43,75	14,21	43,69	14,40	43,62	14,60	43,56	14,79	43,49	14,98	43,43	15,17	43,36	15,35	43,29
47	44,70	14,52	44,63	14,72	44,57	14,91	44,51	15,11	44,44	15,30	44,37	15,50	44,30	15,69	44,23
48	45,65	14,83	45,58	15,03	45,52	15,23	45,45	15,43	45,39	15,63	45,32	15,82	45,25	16,02	45,18
49	46,60	15,14	46,53	15,34	46,47	15,55	46,40	15,75	46,33	15,95	46,26	16,15	46,19	16,36	46,12
50	47,55	15,45	47,48	15,66	47,42	15,86	47,35	16,07	47,28	16,28	47,21	16,48	47,13	16,69	47,06
51	48,50	15,76	48,43	15,97	48,36	16,18	48,29	16,39	48,22	16,60	48,15	16,81	48,07	17,02	48,00
52	49,45	16,07	49,38	16,28	49,31	16,50	49,24	16,71	49,17	16,93	49,09	17,14	49,02	17,36	48,94
53	50,41	16,38	50,33	16,60	50,26	16,82	50,19	17,04	50,11	17,25	50,04	17,47	49,96	17,69	49,88
54	51,36	16,69	51,28	16,91	51,21	17,13	51,13	17,36	51,06	17,58	50,98	17,80	50,90	18,03	50,82
55	52,31	17,00	52,23	17,22	52,16	17,45	52,08	17,68	52,00	17,91	51,92	18,13	51,84	18,36	51,76
56	53,26	17,30	53,18	17,54	53,11	17,80	53,03	18,00	52,95	18,23	52,87	18,46	52,79	18,69	52,71
57	54,21	17,61	54,13	17,85	54,05	18,08	53,98	18,32	53,89	18,56	53,81	18,79	53,73	19,03	53,65
58	55,16	17,92	55,08	18,16	55,00	18,40	54,92	18,64	54,84	18,88	54,76	19,12	54,67	19,36	54,59
59	56,11	18,23	56,03	18,48	55,95	18,72	55,87	18,96	55,79	19,21	55,70	19,45	55,62	19,69	55,53
60	57,06	18,54	56,98	18,79	56,90	19,04	56,82	19,29	56,73	19,53	56,64	19,78	56,56	20,03	56,47
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 M
	72 Deg.		71 Degrees								70 Degrees				

18 Degrees							19 Degrees								
Min.	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		Distance
Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
18,85	57,94	19,10	57,85	19,35	57,76	19,61	57,68	19,86	57,59	20,11	57,50	20,36	57,41	20,61	61
19,16	58,89	19,42	58,80	19,67	58,71	19,93	58,62	20,18	58,53	20,44	58,44	20,70	58,35	20,95	62
19,47	59,84	19,73	59,74	19,99	59,66	20,25	59,57	20,51	59,48	20,77	59,39	21,03	59,29	21,29	63
19,78	60,79	20,04	60,69	20,31	60,60	20,57	60,51	20,84	60,42	21,10	60,33	21,36	60,24	21,63	64
20,09	61,74	20,36	61,64	20,62	61,55	20,89	61,46	21,16	61,36	21,43	61,27	21,70	61,18	21,96	65
20,39	62,69	20,67	62,59	20,94	62,50	21,21	62,40	21,49	62,31	21,76	62,21	22,03	62,12	22,30	66
20,70	63,64	20,98	63,54	21,26	63,44	21,54	63,35	21,81	63,25	22,09	63,16	22,37	63,06	22,64	67
21,01	64,59	21,29	64,49	21,58	64,39	21,86	64,29	22,14	64,20	22,42	64,10	22,70	64,00	22,98	68
21,32	65,54	21,61	65,43	21,89	65,34	22,18	65,24	22,46	65,14	22,75	65,04	23,03	64,94	23,32	69
21,63	66,48	21,12	66,38	22,21	66,28	22,50	66,19	22,79	66,09	23,08	65,98	23,37	65,88	23,65	70
21,94	67,43	22,23	67,33	22,53	67,23	22,82	67,13	23,11	67,03	23,41	66,93	23,70	66,82	23,99	71
22,25	68,38	22,55	68,28	22,85	68,18	23,14	68,07	23,44	67,97	23,74	67,87	24,03	67,76	24,33	72
22,56	69,33	22,86	69,23	23,16	69,13	23,47	69,02	23,76	68,92	24,07	68,81	24,37	68,71	24,67	73
22,87	70,28	23,17	70,18	23,48	70,07	23,79	69,97	24,09	69,86	24,40	69,76	24,70	69,65	25,01	74
23,18	71,23	23,49	71,12	23,80	71,02	24,11	70,91	24,42	70,81	24,73	70,70	25,04	70,59	25,34	75
23,48	72,18	23,80	72,07	24,11	71,97	24,43	71,86	24,74	71,75	25,06	71,64	25,37	71,53	25,68	76
23,79	73,13	24,11	73,02	24,43	72,91	24,75	72,80	25,07	72,69	25,39	72,58	25,70	72,47	26,02	77
24,10	74,08	24,43	73,97	24,75	73,86	25,07	73,75	25,39	73,64	25,72	73,53	26,04	73,41	26,36	78
24,41	75,03	24,74	74,92	25,07	74,81	25,39	74,69	25,72	74,58	26,05	74,47	26,37	74,35	26,70	79
24,72	75,98	25,05	75,87	25,38	75,75	25,71	75,64	26,04	75,53	26,37	75,41	26,70	75,29	27,03	80
25,03	76,92	25,37	76,81	25,70	76,70	26,04	76,59	26,37	76,47	26,70	76,35	27,04	76,23	27,37	81
25,34	77,87	25,68	77,76	26,02	77,65	26,36	77,53	26,70	77,41	27,03	77,30	27,37	77,18	27,71	82
25,65	78,82	25,99	78,71	26,34	78,59	26,68	78,48	27,02	78,36	27,36	78,24	27,71	78,12	28,05	83
25,96	79,77	26,31	79,66	26,65	79,54	27,00	79,42	27,35	79,30	27,69	79,18	28,04	79,06	28,39	84
26,27	80,72	26,62	80,61	26,97	80,49	27,32	80,37	27,67	80,25	28,02	80,12	28,37	80,00	28,72	85
26,58	81,67	26,93	81,56	27,29	81,44	27,64	81,31	28,00	81,19	28,35	81,07	28,71	80,94	29,06	86
26,88	82,62	27,24	82,50	27,60	82,38	27,97	82,26	28,32	82,14	28,68	82,01	29,04	81,88	29,40	87
27,19	83,57	27,56	83,45	27,92	83,33	28,29	83,21	28,65	83,08	29,01	82,95	29,37	82,82	29,74	88
27,50	84,52	27,87	84,40	28,24	84,28	28,61	84,15	28,98	84,02	29,34	83,89	29,71	83,76	30,07	89
27,81	85,47	28,18	85,35	28,56	85,22	28,93	85,10	29,30	84,97	29,67	84,84	30,04	84,71	30,41	90
28,12	86,42	28,50	86,30	28,87	86,17	29,25	86,04	29,63	85,91	30,00	85,78	30,38	85,65	30,75	91
28,43	87,37	28,81	87,25	29,19	87,12	29,57	86,99	29,95	86,86	30,33	86,72	30,71	86,59	31,09	92
28,74	88,32	29,12	88,19	29,51	88,06	29,89	87,93	30,28	87,80	30,66	87,67	31,04	87,53	31,43	93
29,05	89,27	29,44	89,14	29,89	89,01	30,22	88,88	30,60	88,74	30,99	88,61	31,38	88,49	31,76	94
29,36	90,22	29,75	90,09	30,14	89,96	30,54	89,82	30,93	89,69	31,32	89,55	31,71	89,41	32,10	95
29,67	91,17	30,06	91,04	30,46	90,91	30,86	90,77	31,25	90,63	31,65	90,49	32,05	90,35	32,44	96
29,97	92,12	30,38	91,99	30,78	91,85	31,18	91,71	31,58	91,58	31,98	91,44	32,38	91,29	32,78	97
30,28	93,07	30,69	92,93	31,09	92,80	31,50	92,66	31,90	92,52	32,31	92,38	32,71	92,24	33,12	98
30,59	94,02	31,00	93,88	31,41	93,75	31,82	93,61	32,23	93,46	32,64	93,32	33,05	93,18	33,45	99
30,90	94,97	31,32	94,83	31,73	94,69	32,14	94,55	32,56	94,41	32,97	94,26	33,38	94,12	33,79	100
31,21	95,92	31,63	95,78	32,05	95,64	32,46	95,50	32,88	95,35	33,30	95,21	33,71	95,06	34,13	101
31,52	96,87	31,94	96,73	32,36	96,59	32,79	96,44	33,21	96,30	33,63	96,15	34,05	96,00	34,49	102
31,83	97,82	32,25	97,68	32,68	97,53	33,11	97,39	33,53	97,24	33,96	97,09	34,38	96,94	34,81	103
32,14	98,78	32,57	98,62	33,00	98,48	33,43	98,33	33,86	98,18	34,29	98,03	34,72	97,88	35,14	104
32,45	99,73	32,88	99,57	33,32	99,43	33,75	99,28	34,18	99,13	34,62	98,98	35,05	98,82	35,48	105
32,76	100,7	33,19	100,5	33,63	100,4	34,07	100,2	34,51	100,1	34,95	99,92	35,38	99,80	35,82	106
33,06	101,6	33,51	101,5	33,95	101,3	34,39	101,2	34,83	101,0	35,28	100,9	35,72	100,7	36,16	107
33,37	102,6	33,88	102,4	34,27	102,3	34,72	102,1	35,16	102,0	35,61	101,8	36,05	101,7	36,49	108
33,68	103,5	34,13	103,4	34,59	103,2	35,04	103,1	35,48	102,9	35,94	102,7	36,38	102,6	36,83	109
33,99	104,5	34,45	104,3	34,90	104,2	35,36	104,0	35,81	103,9	36,27	103,7	36,72	103,6	37,17	110
34,30	105,4	34,76	105,3	35,22	105,1	35,68	105,0	36,14	104,8	36,60	104,6	37,05	104,5	37,51	111
34,61	106,4	35,07	106,2	35,54	106,1	36,00	105,9	36,46	105,7	36,93	105,6	37,39	105,5	37,85	112
34,92	107,3	35,39	107,2	35,85	107,0	36,22	106,8	36,79	106,7	37,26	106,5	37,72	106,4	38,18	113
35,23	108,3	35,70	108,1	36,17	108,0	36,64	107,8	37,11	107,6	37,58	107,5	38,05	107,3	38,52	114
35,54	109,2	36,01	109,1	36,49	109,9	36,97	108,7	37,44	108,6	37,91	108,4	38,39	108,3	38,86	115
35,85	110,2	36,33	110,0	36,81	109,8	37,29	109,7	37,76	109,5	38,24	109,3	38,72	109,2	39,20	116
36,16	111,1	36,64	111,0	37,12	110,8	37,61	110,6	38,09	110,5	38,57	110,3	39,06	110,2	39,54	117
36,46	112,1	36,95	112,9	37,44	111,7	37,91	111,6	38,42	111,4	38,90	111,2	39,39	111,1	39,87	118
36,77	113,0	37,27	113,9	37,76	112,7	38,25	112,5	38,74	112,3	39,23	112,2	39,72	112,0	40,21	119
37,10	114,0	37,58	114,8	38,08	113,6	38,57	113,5	39,07	113,3	39,56	113,1	40,06	113,0	40,55	120
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	Lat	Distance
Min.	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
Deg.	71 Degrees								70 Degrees						

Diſtance	20 Degrees								21 Degrees						
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
1	0,94	0,34	0,94	0,35	0,94	0,35	0,94	0,35	0,93	0,36	0,93	0,36	0,93	0,37	0,93
2	1,88	0,68	1,88	0,69	1,87	0,70	1,87	0,71	1,87	0,72	1,86	0,73	1,86	0,73	1,86
3	2,82	1,03	2,82	1,04	2,81	1,05	2,81	1,06	2,80	1,08	2,80	1,09	2,79	1,10	2,79
4	3,76	1,37	3,75	1,38	3,75	1,40	3,74	1,42	3,73	1,43	3,73	1,45	3,72	1,47	3,72
5	4,70	1,71	4,69	1,73	4,68	1,75	4,68	1,71	4,67	1,79	4,66	1,81	4,65	1,83	4,64
6	5,64	2,05	5,63	2,08	5,62	2,10	5,61	2,13	5,60	2,15	5,59	2,18	5,58	2,20	5,57
7	6,58	2,39	6,57	2,42	6,56	2,45	6,55	2,48	6,54	2,51	6,52	2,54	6,51	2,57	6,50
8	7,52	2,74	7,51	2,77	7,49	2,80	7,48	2,83	7,47	2,87	7,46	2,90	7,44	2,93	7,43
9	8,46	3,08	8,44	3,12	8,43	3,15	8,42	3,19	8,40	3,23	8,39	3,26	8,37	3,30	8,36
10	9,40	3,42	9,38	3,46	9,37	3,50	9,35	3,54	9,34	3,58	9,32	3,62	9,30	3,67	9,29
11	10,34	3,76	10,32	3,81	10,30	3,85	10,29	3,90	10,27	3,94	10,25	3,99	10,23	4,03	10,22
12	11,28	4,10	11,26	4,15	11,24	4,20	11,22	4,25	11,20	4,30	11,18	4,35	11,17	4,40	11,15
13	12,22	4,45	12,20	4,50	12,18	4,55	12,16	4,61	12,14	4,66	12,12	4,71	12,10	4,77	12,07
14	13,16	4,79	13,14	4,85	13,11	4,90	13,09	4,96	13,07	5,02	13,05	5,07	13,03	5,13	13,00
15	14,10	5,13	14,07	5,19	14,05	5,25	14,03	5,31	14,00	5,38	13,98	5,44	13,96	5,50	13,93
16	15,04	5,47	15,01	5,54	14,99	5,60	14,96	5,67	14,94	5,73	14,91	5,80	14,89	5,86	14,86
17	15,98	5,81	15,95	5,88	15,92	5,95	15,90	6,02	15,87	6,09	15,84	6,16	15,82	6,23	15,79
18	16,92	6,16	16,89	6,23	16,86	6,30	16,83	6,38	16,80	6,45	16,78	6,52	16,75	6,60	16,72
19	17,85	6,50	17,83	6,58	17,80	6,65	17,77	6,73	17,74	6,81	17,71	6,89	17,68	6,96	17,65
20	18,79	6,84	18,76	6,92	18,73	7,00	18,70	7,09	18,67	7,17	18,64	7,25	18,61	7,33	18,58
21	19,73	7,18	19,71	7,27	19,67	7,35	19,64	7,44	19,61	7,53	19,57	7,61	19,54	7,70	19,51
22	20,67	7,52	20,64	7,61	20,61	7,71	20,57	7,80	20,54	7,88	20,50	7,97	20,47	8,06	20,43
23	21,61	7,87	21,58	7,96	21,54	8,06	21,51	8,15	21,47	8,24	21,44	8,34	21,40	8,43	21,36
24	22,55	8,21	22,52	8,31	22,48	8,41	22,45	8,50	22,41	8,60	22,37	8,70	22,33	8,80	22,29
25	23,49	8,55	23,46	8,65	23,42	8,76	23,38	8,86	23,34	8,96	23,30	9,06	23,26	9,16	23,22
26	24,43	8,89	24,39	9,00	24,35	9,11	24,31	9,21	24,27	9,32	24,23	9,42	24,19	9,53	24,15
27	25,37	9,23	25,33	9,35	25,29	9,46	25,25	9,57	25,21	9,68	25,16	9,79	25,12	9,90	25,08
28	26,31	9,58	26,27	9,69	26,23	9,81	26,18	9,92	26,14	10,03	26,10	10,15	26,05	10,26	26,01
29	27,25	9,92	27,21	10,04	27,16	10,16	27,12	10,27	27,07	10,39	27,03	10,51	26,98	10,63	26,94
30	28,19	10,26	28,15	10,38	28,10	10,51	28,05	10,63	28,01	10,75	27,96	10,87	27,91	11,00	27,86
31	29,13	10,60	29,08	10,73	29,04	10,86	28,99	10,98	28,94	11,11	28,89	11,24	28,84	11,36	28,79
32	36,07	10,95	30,02	11,08	29,97	11,21	29,93	11,34	29,87	11,47	29,82	11,60	29,77	11,73	29,72
33	31,01	11,29	30,96	11,42	30,91	11,56	30,86	11,69	30,81	11,83	30,76	11,96	30,70	12,10	30,65
34	31,95	11,63	31,90	11,77	31,85	11,91	31,80	12,05	31,74	12,18	31,69	12,32	31,64	12,46	31,58
35	32,89	11,97	32,84	12,12	32,78	12,26	32,73	12,40	32,68	12,54	32,62	12,69	32,57	12,83	32,51
36	33,83	12,31	33,78	12,46	33,72	12,61	33,67	12,76	33,61	2,90	33,55	13,05	33,50	13,19	33,44
37	34,77	12,66	34,71	12,81	34,66	12,96	34,60	13,11	34,54	13,26	34,48	13,41	34,43	13,56	34,37
38	35,71	13,00	35,62	13,15	35,59	13,31	35,54	13,46	35,48	13,62	35,41	13,77	35,36	13,93	35,29
39	36,65	13,34	36,59	13,50	36,53	13,66	36,47	13,82	36,41	13,98	36,35	14,14	36,29	14,29	36,22
40	37,59	13,68	37,53	13,85	37,47	14,01	37,41	14,17	37,34	14,36	37,28	14,50	37,22	14,66	37,15
41	38,53	14,02	38,47	14,19	38,40	14,36	38,34	14,53	38,28	14,69	38,21	14,86	38,15	15,03	38,08
42	39,47	14,37	39,40	14,54	39,34	14,71	39,28	14,88	39,21	15,05	39,14	15,22	39,08	15,39	39,01
43	40,41	14,71	40,34	14,88	40,28	15,06	40,21	15,23	40,14	15,41	40,08	15,59	40,01	15,76	39,94
44	41,35	15,05	41,28	15,23	41,21	15,41	41,15	15,59	41,08	15,77	41,01	15,95	40,94	16,13	40,87
45	42,29	15,39	42,22	15,58	42,15	15,76	42,08	15,94	42,01	16,13	41,94	16,31	41,87	16,49	41,80
46	43,23	15,73	43,16	15,92	43,09	16,11	43,02	16,30	42,94	16,49	42,87	16,67	42,80	16,86	42,73
47	44,17	16,08	44,10	16,27	44,02	16,46	43,95	16,65	43,88	16,84	43,80	17,04	43,73	17,23	43,65
48	45,11	16,42	45,03	16,6	44,96	16,81	44,89	17,01	44,81	17,20	44,74	17,40	44,66	17,59	44,58
49	46,05	16,76	45,97	16,96	45,90	17,16	45,82	17,36	45,75	7,56	45,67	17,76	45,59	17,96	45,51
50	46,99	17,10	46,91	17,31	46,83	17,51	46,76	17,72	46,68	17,92	46,60	18,12	46,52	18,33	46,44
51	47,93	17,44	47,85	17,65	47,77	17,86	47,69	18,07	47,61	18,28	47,53	18,49	47,45	18,69	47,37
52	48,86	17,79	48,79	18,00	48,71	18,21	48,61	18,42	48,54	18,64	48,47	18,85	48,38	19,06	48,30
53	49,80	18,13	49,73	18,34	49,64	18,56	49,56	18,78	49,48	18,99	49,40	19,21	49,31	19,43	49,23
54	50,74	18,47	50,66	18,69	50,58	18,91	50,50	19,13	50,41	19,35	50,33	19,57	50,24	19,79	50,16
55	51,68	18,81	51,60	19,04	51,52	19,26	51,43	19,49	51,35	19,71	51,26	19,94	51,17	20,16	51,09
56	52,62	19,15	52,54	19,38	52,45	19,61	52,37	19,84	52,28	20,07	52,19	20,30	52,10	20,52	52,01
57	53,56	19,50	53,46	19,73	53,39	19,96	53,30	20,20	53,21	20,43	53,13	20,66	53,03	20,89	52,94
58	54,50	19,84	54,42	20,08	54,33	20,31	54,24	20,55	54,15	20,79	54,06	21,02	53,96	21,26	53,87
59	55,44	20,18	55,35	20,42	55,26	20,66	55,17	20,90	55,08	21,14	54,99	21,38	54,90	21,62	54,80
60	56,36	20,52	56,39	20,77	56,20	21,01	56,11	21,26	56,02	21,50	55,92	21,75	55,83	21,99	55,73
Diſtance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15
	70 Deg.		69 Degrees								68 Degrees				

20 Degrees								21 Degrees								Distance
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
at.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
7,32	20,86	57,23	21,11	57,14	21,36	57,04	21,61	56,95	21,86	56,85	22,11	56,76	22,36	56,66	22,60	61
8,26	21,21	58,17	21,46	58,07	21,71	57,98	21,97	57,88	22,22	57,79	22,47	57,69	22,73	57,59	22,98	62
,20	21,55	59,11	21,81	59,01	22,06	58,91	22,32	58,82	22,58	58,72	22,83	58,62	23,09	58,52	23,35	63
,14	21,89	60,04	22,15	59,95	22,41	59,85	22,67	59,75	22,94	59,65	23,20	59,55	23,46	59,44	23,72	64
,08	22,23	60,98	22,50	60,88	22,76	60,79	23,03	60,68	23,29	60,58	23,56	60,48	23,82	60,37	24,09	65
,02	22,57	61,92	22,84	61,82	23,11	61,72	23,38	61,62	23,65	61,51	23,92	61,41	24,19	61,30	24,46	66
,96	22,92	62,86	23,19	62,76	23,46	62,66	23,74	62,55	24,01	62,45	24,28	62,34	24,56	62,23	24,83	67
,90	23,26	63,80	23,54	63,69	23,82	63,59	24,09	63,48	24,37	63,38	24,65	63,27	24,92	63,16	25,20	68
,84	23,60	64,74	23,88	64,63	24,17	64,53	24,4	64,42	24,73	64,31	25,01	64,20	25,29	64,09	25,57	69
,78	23,94	65,67	24,23	65,57	24,52	65,46	24,80	65,35	25,09	65,24	25,37	65,13	25,66	65,02	25,94	70
,72	24,28	66,61	24,57	66,50	24,87	66,40	25,15	66,28	25,44	66,17	25,73	66,06	26,02	65,95	26,31	71
,66	24,63	67,55	24,92	67,44	25,22	67,33	25,51	67,22	25,80	67,11	26,10	66,99	26,39	66,88	26,68	72
,60	24,97	68,49	25,27	68,38	25,57	68,27	25,86	68,15	26,16	68,04	26,46	67,92	26,76	67,80	27,05	73
,54	25,31	69,43	25,61	69,31	25,92	69,20	26,22	69,09	26,52	68,97	26,82	68,85	27,12	68,73	27,42	74
,48	25,65	70,36	25,96	70,25	26,27	70,14	26,57	70,02	26,88	69,90	27,18	69,78	27,49	69,66	27,79	75
,42	25,99	71,30	26,31	71,19	26,62	71,07	26,93	70,95	27,24	70,83	27,55	70,71	27,85	70,59	28,16	76
,36	26,34	72,24	26,65	72,12	26,97	72,01	27,28	71,89	27,59	71,77	27,91	71,64	28,22	71,52	28,52	77
,30	26,68	73,18	27,00	73,06	27,31	72,94	27,63	72,82	27,95	72,70	28,27	72,57	28,59	72,45	28,90	78
,24	27,02	74,12	27,34	74,00	27,67	73,88	27,99	73,75	28,31	73,63	28,62	73,50	28,95	73,38	29,27	79
,18	27,36	75,06	27,69	74,93	28,02	74,81	28,34	74,69	28,67	74,56	29,00	74,43	29,32	74,31	29,65	80
,12	27,70	75,99	28,04	75,87	28,37	75,75	28,70	75,62	29,03	75,49	29,36	75,37	29,69	75,23	30,02	81
,05	28,05	76,93	28,38	76,81	28,72	76,68	29,05	76,55	29,39	76,43	29,72	76,30	30,05	76,16	30,39	82
,99	28,39	77,87	28,73	77,74	29,07	77,62	29,41	77,49	29,75	77,36	30,08	77,23	30,42	77,09	30,76	83
,93	28,73	78,81	29,07	78,68	29,42	78,55	29,76	78,42	30,10	78,29	30,45	78,16	30,79	78,02	31,13	84
,87	29,07	79,75	29,42	79,62	29,77	79,49	30,11	79,35	30,46	79,22	30,81	79,09	31,15	78,9	31,50	85
81	29,41	80,68	29,77	80,55	30,12	80,42	30,47	80,29	30,82	80,15	31,17	80,02	31,52	79,88	31,87	86
75	29,76	81,62	30,11	81,49	31,47	81,36	30,82	81,22	31,16	81,09	31,53	80,95	31,89	80,81	32,24	87
69	30,10	82,56	30,46	82,43	31,82	82,29	31,18	82,15	31,54	82,02	31,89	81,88	32,25	81,74	32,61	88
63	30,44	83,50	30,81	83,36	31,17	83,23	31,53	83,09	31,90	82,95	32,26	82,81	32,62	82,66	32,98	89
,57	30,78	84,44	31,15	84,30	31,52	84,16	31,89	84,02	32,25	83,88	32,62	83,74	32,99	83,59	33,35	90
51	31,12	85,38	31,50	85,24	31,87	85,10	32,24	84,96	32,61	84,81	32,98	84,67	33,35	84,52	33,72	91
,45	31,47	86,31	31,84	86,17	32,22	86,03	32,60	85,89	32,97	85,75	33,35	85,60	33,72	85,45	34,09	92
39	31,81	87,25	32,19	87,11	32,57	86,97	32,95	86,82	33,33	86,68	33,71	86,53	34,09	86,38	34,46	93
33	32,1	88,19	32,54	88,05	32,92	87,90	33,3	87,76	33,69	87,61	34,07	87,46	34,45	87,31	34,83	94
27	32,49	89,13	32,88	88,98	33,27	88,84	33,6	88,69	34,04	88,54	34,43	88,39	34,82	88,24	35,20	95
21	32,83	90,07	33,23	89,92	33,62	89,77	34,01	89,62	34,40	89,47	34,80	89,32	35,18	89,17	35,57	96
15	33,18	91,00	33,57	90,86	33,97	90,71	34,37	90,56	34,76	90,41	35,16	90,25	35,55	90,10	35,94	97
09	33,52	91,94	33,92	91,79	34,32	91,64	34,72	91,49	35,11	91,34	35,52	91,18	35,92	91,02	36,31	98
03	33,86	92,88	34,27	92,73	34,67	92,58	35,07	92,42	35,48	92,27	35,88	92,11	36,28	91,95	36,69	99
97	34,20	93,82	34,61	93,67	35,02	93,51	35,43	93,36	35,84	93,20	36,22	93,04	36,65	92,88	37,06	100
91	34,54	94,76	34,96	94,60	35,37	94,45	35,78	94,29	36,20	94,13	36,61	93,97	37,02	93,81	37,43	101
85	34,89	95,70	35,30	95,54	35,72	95,39	36,14	95,23	36,55	95,06	36,97	94,90	37,38	94,74	37,80	102
79	35,23	96,63	35,65	96,48	36,07	96,32	36,49	96,16	36,92	96,00	37,33	95,83	37,75	95,67	38,17	103
73	35,57	97,57	36,00	97,41	36,42	97,26	36,85	97,09	37,27	96,93	37,70	96,76	38,12	96,60	38,54	104
67	35,91	98,51	36,34	98,35	36,77	98,19	37,20	98,03	37,63	97,86	38,06	97,69	38,48	97,53	38,91	105
61	36,25	99,45	36,69	99,29	37,12	99,12	37,56	98,96	37,99	98,79	38,42	98,63	38,85	98,45	39,28	106
,5	36,60	100,4	37,04	100,2	37,47	100,1	37,91	99,89	38,35	99,73	38,78	99,56	39,22	99,38	39,65	107
,5	36,94	101,3	37,38	101,2	37,82	101,0	38,26	100,8	38,70	100,7	39,14	100,5	39,58	100,3	40,02	108
,4	37,28	102,3	37,73	102,1	38,17	101,9	38,62	101,8	39,06	101,6	39,51	101,4	39,94	101,2	40,39	109
,4	37,62	103,2	38,07	103,0	38,52	102,9	38,97	102,7	39,42	102,5	39,87	102,3	40,32	102,2	40,76	110
,3	37,96	104,1	38,42	104,0	38,87	103,8	39,33	103,6	39,78	103,5	40,23	103,3	40,68	103,1	41,13	111
,2	38,31	105,1	38,77	104,9	39,22	104,7	39,68	104,6	40,14	104,4	40,59	104,2	41,05	104,0	41,50	112
,2	38,65	106,0	39,11	105,8	39,57	105,7	40,04	105,5	40,50	105,3	40,96	105,1	41,42	105,0	41,87	113
,1	38,99	107,0	39,46	106,8	39,92	106,6	40,39	106,4	40,85	106,2	41,32	106,1	41,78	105,9	42,24	114
,1	39,33	107,9	39,80	107,7	40,27	107,5	40,74	107,4	41,21	107,2	41,68	107,0	42,15	106,8	42,61	115
,0	39,67	108,8	40,15	108,7	40,62	108,5	41,10	108,3	41,57	108,1	42,04	107,9	42,51	107,7	42,99	116
,9	40,02	109,8	40,50	109,6	40,97	109,4	41,45	109,2	41,93	109,0	42,41	108,9	42,88	108,7	43,36	117
,9	40,36	110,7	40,84	110,5	41,32	110,3	41,81	110,2	42,29	110,0	42,77	109,8	43,25	109,6	43,73	118
,8	40,70	111,6	41,19	111,5	41,67	111,3	42,16	111,1	42,65	110,9	43,13	110,7	43,61	110,5	44,10	119
,8	41,04	112,6	41,53	112,4	42,03	112,2	42,92	112,0	43,00	111,8	43,49	111,7	43,98	111,5	44,47	120
p.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
Deg.		69 Degrees								68 Degrees						

Distance	22 Degrees								23 Degrees							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
1	0,93	0,38	0,93	0,38	0,92	0,38	0,92	0,39	0,92	0,39	0,92	0,40	0,92	0,40	0,92	0,40
2	1,85	0,75	1,85	0,76	1,85	0,77	1,84	0,77	1,84	0,78	1,84	0,79	1,83	0,80	1,83	0,81
3	2,78	1,12	2,78	1,14	2,77	1,15	2,77	1,16	2,76	1,17	2,76	1,18	2,75	1,20	2,75	1,21
4	3,71	1,50	3,70	1,52	3,70	1,53	3,69	1,55	3,68	1,56	3,68	1,58	3,67	1,60	3,66	1,61
5	4,64	1,87	4,63	1,89	4,62	1,91	4,61	1,93	4,60	1,95	4,59	1,97	4,59	1,99	4,58	2,01
6	5,56	2,25	5,55	2,27	5,54	2,30	5,53	2,32	5,52	2,34	5,51	2,37	5,50	2,39	5,49	2,42
7	6,49	2,62	6,48	2,65	6,47	2,68	6,46	2,71	6,44	2,74	6,43	2,76	6,42	2,79	6,41	2,82
8	7,42	3,00	7,40	3,03	7,39	3,06	7,38	3,09	7,36	3,13	7,35	3,16	7,34	3,19	7,32	3,22
9	8,35	3,37	8,33	3,41	8,32	3,44	8,30	3,48	8,29	3,52	8,27	3,55	8,25	3,59	8,24	3,63
10	9,27	3,75	9,26	3,79	9,24	3,83	9,22	3,87	9,21	3,91	9,19	3,95	9,17	3,99	9,15	4,03
11	10,20	4,12	10,18	4,17	10,16	4,21	10,14	4,25	10,13	4,30	10,11	4,34	10,09	4,39	10,07	4,43
12	11,13	4,50	11,11	4,54	11,09	4,59	11,07	4,64	11,05	4,70	11,03	4,74	11,01	4,79	10,98	4,83
13	12,05	4,87	12,03	4,92	12,01	4,97	11,99	5,03	11,97	5,08	11,94	5,13	11,92	5,18	11,90	5,24
14	12,98	5,24	12,96	5,30	12,94	5,36	12,91	5,41	12,89	5,47	12,86	5,53	12,84	5,58	12,81	5,64
15	13,91	5,62	13,88	5,68	13,86	5,74	13,83	5,80	13,81	5,86	13,78	5,92	13,76	5,98	13,73	6,04
16	14,84	5,99	14,81	6,06	14,78	6,12	14,76	6,19	14,73	6,25	14,70	6,32	14,67	6,38	14,65	6,44
17	15,76	6,37	15,73	6,44	15,71	6,51	15,68	6,57	15,65	6,64	15,62	6,71	15,59	6,78	15,56	6,85
18	16,69	6,74	16,66	6,82	16,63	6,89	16,60	6,96	16,57	7,03	16,54	7,11	16,51	7,18	16,48	7,25
19	17,62	7,12	17,59	7,19	17,55	7,27	17,52	7,35	17,49	7,42	17,46	7,50	17,42	7,58	17,39	7,65
20	18,54	7,49	18,51	7,57	18,48	7,65	18,44	7,73	18,41	7,82	18,38	7,90	18,34	7,98	18,31	8,06
21	19,47	7,87	19,44	7,95	19,40	8,04	19,37	8,12	19,33	8,21	19,30	8,29	19,26	8,37	19,22	8,46
22	20,40	8,24	20,36	8,33	20,33	8,42	20,29	8,51	20,25	8,60	20,21	8,69	20,18	8,77	20,14	8,86
23	21,33	8,62	21,29	8,71	21,25	8,80	21,21	8,89	21,17	8,99	21,13	9,08	21,09	9,17	21,05	9,26
24	22,25	8,99	22,21	9,09	22,17	9,18	22,13	9,28	22,09	9,38	22,05	9,47	22,01	9,57	21,97	9,66
25	23,18	9,37	23,14	9,47	23,10	9,57	23,05	9,67	23,01	9,77	22,97	9,87	22,93	9,97	22,88	10,07
26	24,11	9,74	24,06	9,84	24,02	9,95	23,98	10,05	23,93	10,16	23,89	10,26	23,84	10,37	23,80	10,47
27	25,03	10,11	24,99	10,22	24,95	10,33	24,90	10,44	24,85	10,55	24,81	10,66	24,76	10,77	24,71	10,87
28	25,96	10,49	25,91	10,60	25,87	10,72	25,82	10,83	25,77	10,94	25,73	11,05	25,68	11,16	25,63	11,28
29	26,89	10,86	26,84	10,98	26,79	11,10	26,74	11,21	26,70	11,33	26,65	11,45	26,60	11,56	26,54	11,68
30	27,82	11,24	27,77	11,36	27,72	11,48	27,67	11,60	27,62	11,72	27,56	11,84	27,51	11,96	27,46	12,08
31	28,74	11,61	28,69	11,74	28,64	11,86	28,59	11,99	28,54	12,11	28,48	12,24	28,43	12,36	28,37	12,49
32	29,67	11,99	29,62	12,12	29,56	12,25	29,51	12,38	29,46	12,50	29,40	12,63	29,35	12,76	29,29	12,89
33	30,60	12,36	30,54	12,50	30,49	12,63	30,43	12,76	30,38	12,89	30,32	13,03	30,26	13,16	30,21	13,29
34	31,52	12,74	31,47	12,87	31,41	13,01	31,36	13,15	31,30	13,28	31,24	13,42	31,18	13,56	31,12	13,69
35	32,45	13,11	32,39	13,25	32,34	13,39	32,28	13,54	32,22	13,68	32,16	13,82	32,10	13,96	32,04	14,10
36	33,38	13,49	33,32	13,63	33,26	13,78	33,20	13,92	33,14	14,07	33,08	14,21	33,01	14,36	32,95	14,50
37	34,31	13,86	34,25	14,01	34,18	14,16	34,12	14,31	34,06	14,46	34,00	14,61	33,93	14,75	33,87	14,90
38	35,23	14,24	35,17	14,39	35,11	14,54	35,04	14,69	34,98	14,85	34,91	15,00	34,85	15,15	34,78	15,30
39	36,16	14,61	36,10	14,77	36,03	14,92	35,97	15,08	35,90	15,24	35,83	15,40	35,77	15,55	35,70	15,71
40	37,09	14,98	37,02	15,15	36,96	15,30	36,89	15,47	36,82	15,63	36,75	15,79	36,68	15,95	36,61	16,11
41	38,01	15,36	37,95	15,52	37,88	15,69	37,81	15,86	37,74	16,02	37,67	16,19	37,60	16,35	37,53	16,51
42	38,94	15,73	38,87	15,90	38,80	16,07	38,73	16,24	38,66	16,41	38,59	16,59	38,52	16,75	38,44	16,92
43	39,87	16,10	39,80	16,28	39,73	16,45	39,66	16,63	39,58	16,80	39,51	16,97	39,43	17,15	39,36	17,32
44	40,80	16,48	40,72	16,66	40,65	16,84	40,58	17,02	40,50	17,19	40,43	17,37	40,35	17,54	40,27	17,72
45	41,72	16,86	41,65	17,04	41,57	17,22	41,50	17,40	41,42	17,58	41,35	17,76	41,27	17,94	41,19	18,12
46	42,65	17,23	42,58	17,42	42,50	17,60	42.42	17,79	42,34	17,97	42,27	18,16	42,18	18,34	42,10	18,53
47	43,58	17,61	43,50	17,80	43,42	17,99	43,34	18,18	43,26	18,36	43,18	18,55	43,10	18,74	43,02	18,93
48	44,51	17,98	44,43	18,18	44,35	18,37	44,27	18,56	44,18	18,76	44,10	18,95	44,02	19,14	43,93	19,33
49	45,43	18,36	45,35	18,55	45,27	18,75	45,19	18,95	45,11	19,15	45,02	19,34	44,94	19,54	44,85	19,73
50	46,36	18,73	46,28	18,93	46,19	19,13	46,11	19,34	46,03	19,54	45,94	19,74	45,85	19,94	45,77	20,14
51	47,29	19,11	47,20	19,31	47,12	19,52	47,03	19,72	46,95	19,93	46,86	20,13	46,77	20,34	46,68	20,54
52	48,21	19,48	48,13	19,69	48,04	19,90	47,95	20,11	47,87	20,32	47,78	20,53	47,69	20,74	47,60	20,94
53	49,14	19,86	49,05	20,07	48,97	20,28	48,88	20,50	48,79	20,71	48,70	20,92	48,60	21,13	48,51	21,35
54	50,07	20,23	49,98	20,45	49,89	20,66	49,80	20,88	49,71	21,10	49,62	21,32	49,52	21,53	49,43	21,75
55	51,00	20,60	50,90	20,83	50,81	21,05	50,72	21,27	50,63	21,49	50,53	21,71	50,44	21,93	50,34	22,15
56	51,92	20,98	51,83	21,20	51,74	21,43	51,64	21,66	51,55	21,88	51,45	22,11	51,36	22,33	51,26	22,55
57	52,85	21,35	52,76	21,58	52,65	21,81	52,57	22,04	52,46	22,27	52,37	22,50	52,27	22,73	52,17	22,96
58	53,78	21,73	53,68	21,96	53,59	22,20	53,49	22,43	53,39	22,66	53,29	22,90	53,19	23,13	53,09	23,36
59	54,70	22,10	54,61	22,34	54,51	22,58	54,41	22,82	54,31	23,05	54,21	23,29	54,11	23,53	54,00	23,76
60	55,63	22,48	55,53	22,72	55,43	22,96	55,32	23,20	55,23	23,44	55,13	23,68	55,02	23,93	54,92	24,17
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.	
	68 Deg.		67 Degrees								66 Degrees					

22 Degrees								23 Degrees								
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Distance
6,56	22,85	56,46	23,10	56,36	23,34	56,25	23,59	56,15	23,83	56,05	24,08	55,94	24,32	55,83	24,57	61
7,49	23,23	57,38	23,48	57,28	23,73	57,18	23,98	57,07	24,22	56,97	24,47	56,86	24,72	56,75	24,97	62
8,41	23,60	58,31	23,86	58,21	24,11	58,10	24,37	57,99	24,62	57,88	24,87	57,78	25,12	57,66	25,37	63
9,34	23,98	59,23	24,23	59,13	24,49	59,02	24,75	58,91	25,01	58,80	25,26	58,69	25,52	58,58	25,78	64
0,27	24,35	60,16	24,61	60,05	24,87	59,94	25,14	59,83	25,40	59,72	25,66	59,61	25,92	59,49	26,18	65
1,19	24,72	61,08	24,99	60,98	25,26	60,87	25,52	60,75	25,79	60,64	26,05	60,53	26,32	60,41	26,58	66
2,12	25,10	62,01	25,37	61,90	25,63	61,79	25,91	61,67	26,18	61,56	26,45	61,44	26,72	61,32	26,99	67
3,05	25,47	62,94	25,75	62,82	26,02	62,71	26,30	62,59	26,57	62,48	26,84	62,36	27,12	62,24	27,39	68
3,98	25,85	63,86	26,13	63,75	26,41	63,63	26,68	63,52	26,96	63,40	27,23	63,28	27,52	63,15	27,79	69
4,90	26,22	64,79	26,51	64,67	26,79	64,55	27,07	64,44	27,35	64,32	27,63	64,19	27,91	64,07	28,19	70
5,83	26,60	65,71	26,89	65,60	27,17	65,48	27,46	65,36	27,74	65,23	28,03	65,11	28,31	64,99	28,60	71
6,76	26,97	66,64	27,26	66,52	27,55	66,40	27,84	66,28	28,13	66,15	28,42	66,03	28,71	65,90	29,00	72
7,69	27,35	67,57	27,64	67,44	27,94	67,32	28,22	67,20	28,52	67,07	28,82	66,95	29,11	66,82	29,40	73
8,61	27,72	68,49	28,02	68,37	28,32	68,24	28,62	68,12	28,91	67,99	29,21	67,86	29,51	67,73	29,81	74
9,54	28,10	69,42	28,40	69,29	28,70	69,17	29,00	69,04	29,30	68,91	29,61	68,78	29,91	68,65	30,21	75
0,47	28,47	70,34	28,78	70,21	29,08	70,09	29,39	69,96	29,69	69,83	30,00	69,70	30,31	69,56	30,61	76
1,39	28,85	71,27	29,16	71,14	29,47	71,01	29,78	70,88	30,09	70,71	30,40	70,01	30,70	70,48	31,01	77
2,32	29,22	72,19	29,54	72,06	29,85	71,93	30,16	71,80	30,46	71,67	30,79	71,53	31,11	71,39	31,42	78
3,25	29,59	73,12	29,91	72,99	30,23	72,85	30,55	72,72	30,87	72,59	31,19	72,45	31,50	72,31	31,82	79
4,17	29,97	74,04	30,29	73,91	30,61	73,78	30,94	73,64	31,26	73,50	31,58	73,37	31,90	73,23	32,22	80
5,10	30,34	74,97	30,67	74,83	31,00	74,70	31,32	74,56	31,65	74,42	31,97	74,28	32,30	74,14	32,62	81
6,03	30,72	75,89	31,05	75,76	31,38	75,62	31,71	75,48	32,04	75,34	32,37	75,20	32,70	75,06	33,03	82
6,96	31,09	76,82	31,43	76,68	31,76	76,54	32,09	76,40	32,43	76,26	32,76	76,12	33,10	75,97	33,43	83
7,88	31,47	77,75	31,81	77,61	32,15	77,47	32,48	77,32	32,82	77,18	33,15	77,03	33,50	76,89	33,83	84
8,81	31,84	78,67	32,19	78,53	32,53	78,39	32,87	78,24	33,21	78,10	33,55	77,95	33,90	77,80	34,24	85
9,74	32,22	79,60	32,56	79,45	32,91	79,31	33,26	79,16	33,60	79,02	33,95	78,87	34,29	78,71	34,64	86
0,66	32,59	80,52	32,94	80,38	33,29	80,23	33,64	80,08	34,00	79,94	34,34	79,78	34,69	79,63	35,04	87
1,59	32,97	81,45	33,32	81,30	33,68	81,18	34,03	81,00	34,39	80,86	34,73	80,71	35,09	80,55	35,44	88
2,52	33,34	82,37	33,70	82,23	34,06	82,08	34,42	81,93	34,78	81,77	35,13	81,62	35,49	81,46	35,85	89
3,45	33,72	83,30	34,08	83,15	34,44	83,00	34,80	82,85	35,17	82,69	35,53	82,54	35,89	82,38	36,25	90
4,37	34,09	84,22	34,46	84,07	34,82	83,92	35,19	83,77	35,56	83,61	35,92	83,46	36,29	83,29	36,65	91
5,30	34,46	85,15	34,84	85,00	35,21	84,84	35,57	84,69	35,95	84,53	36,32	84,37	36,69	84,21	37,05	92
6,23	34,84	86,08	35,22	85,92	35,59	85,77	35,97	85,61	36,34	85,45	36,71	85,29	37,09	85,12	37,46	93
7,16	35,21	87,00	35,59	86,85	35,97	86,69	36,35	86,53	36,73	86,37	37,11	86,20	37,48	86,04	37,86	94
8,08	35,59	87,92	35,97	87,77	36,35	87,61	36,74	87,45	37,12	87,29	37,50	87,12	37,88	86,95	38,26	95
9,01	35,96	88,85	36,35	88,69	36,74	88,53	37,12	88,37	37,51	88,21	37,90	88,04	38,28	87,87	38,67	96
9,94	36,34	89,78	36,73	89,62	37,12	89,45	37,51	89,29	37,90	89,12	38,29	88,95	38,68	88,78	39,07	97
0,86	36,71	90,70	37,11	90,54	37,50	90,38	37,90	90,21	38,29	90,04	38,69	89,87	39,08	89,70	39,47	98
1,79	37,09	91,63	37,49	91,46	37,89	91,30	38,28	91,13	38,69	90,96	39,08	90,79	39,48	90,61	39,88	99
2,72	37,46	92,55	37,87	92,39	38,27	92,22	38,67	92,05	39,07	91,88	39,47	91,71	39,88	91,53	40,28	100
3,65	37,84	93,48	38,24	93,31	38,65	93,14	39,06	92,97	39,46	92,80	39,87	92,63	40,28	92,45	40,68	101
4,57	38,21	94,41	38,62	94,24	39,03	94,06	39,45	93,89	39,86	93,72	40,26	93,54	40,67	93,36	41,08	102
5,50	38,59	95,33	39,00	95,16	39,42	94,98	39,83	94,81	40,25	94,63	40,66	94,46	41,07	94,28	41,48	103
6,43	38,96	96,26	39,38	96,08	39,80	95,91	40,22	95,73	40,64	95,50	41,05	95,37	41,47	95,19	41,89	104
7,35	39,33	97,18	39,76	97,01	40,18	96,83	40,61	96,65	41,03	96,47	41,45	96,29	41,87	96,11	42,29	105
8,28	39,71	98,11	40,14	97,93	40,56	97,75	40,99	97,57	41,42	97,39	41,84	97,21	42,27	97,02	42,69	106
9,21	40,08	99,03	40,52	98,86	40,95	98,68	41,38	98,49	41,81	98,31	42,24	98,13	42,67	97,94	43,10	107
00,1	40,46	99,96	40,89	99,78	41,33	99,60	41,76	99,41	42,20	99,23	42,63	99,04	43,07	98,85	43,50	108
01,1	40,83	100,9	41,27	100,7	41,71	100,5	42,15	100,3	42,59	100,2	43,03	99,96	43,47	99,77	43,90	109
02,0	41,21	101,8	41,65	101,6	42,10	101,4	42,54	101,3	42,98	101,1	43,42	100,9	43,86	100,7	44,30	110
02,9	41,58	102,7	42,03	102,6	42,48	102,4	42,93	102,2	43,37	102,0	43,82	101,8	44,26	101,6	44,71	111
03,8	41,96	103,7	42,41	103,5	42,86	103,3	43,31	103,1	43,76	102,9	44,21	102,7	44,66	102,5	45,11	112
04,8	42,33	104,6	42,79	104,4	43,24	104,2	43,70	104,0	44,15	103,8	44,61	103,6	45,06	103,4	45,51	113
05,7	42,71	105,5	43,17	105,3	43,63	105,1	44,09	104,9	44,54	104,7	45,00	104,5	45,46	104,3	45,92	114
06,6	43,08	106,4	43,55	106,2	44,01	106,1	44,47	105,9	44,94	105,7	45,40	105,5	45,86	105,3	46,32	115
07,6	43,45	107,4	43,92	107,2	44,39	107,0	44,86	106,8	45,33	106,6	45,79	106,4	46,26	106,2	46,72	116
08,5	43,83	108,3	44,30	108,1	44,77	107,9	45,25	107,7	45,72	107,5	46,19	107,3	46,66	107,1	47,12	117
09,4	44,21	109,2	44,68	109,0	45,16	108,8	45,63	108,6	46,11	108,4	46,58	108,2	47,06	108,0	47,52	118
10,3	44,58	110,1	45,06	109,9	45,54	109,7	46,02	109,5	46,50	109,3	46,98	109,1	47,45	108,9	47,93	119
11,3	44,95	111,1	45,44	110,9	46,92	110,7	46,41	110,5	46,89	110,3	47,31	110,0	47,85	109,8	48,33	120
Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
68 Deg.		67 Degrees								66 Degrees						

Distance	24 Degrees								25 Degrees								
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,91	0,41	0,91	0,41	0,91	0,42	0,91	0,42	0,91	0,42	0,90	0,43	0,90	0,43	0,90	0,43	
2	1,83	0,81	1,82	0,82	1,82	0,83	1,82	0,84	1,81	0,85	1,81	0,85	1,81	0,86	1,80	0,87	
3	2,74	1,22	2,74	1,23	2,73	1,24	2,72	1,26	2,72	1,27	2,71	1,28	2,71	1,29	2,70	1,30	
4	3,65	1,63	3,65	1,64	3,64	1,66	3,63	1,68	3,63	1,69	3,62	1,71	3,61	1,72	3,60	1,74	
5	4,57	2,03	4,56	2,05	4,55	2,07	4,54	2,09	4,58	2,11	4,52	2,13	4,51	2,15	4,50	2,17	
6	5,48	2,44	5,47	2,46	5,46	2,49	5,45	2,51	5,44	2,54	5,43	2,56	5,42	2,58	5,40	2,61	
7	6,40	2,85	6,38	2,88	6,37	2,90	6,36	2,93	6,34	2,96	6,33	2,99	6,32	3,01	6,31	3,04	
8	7,31	3,25	7,29	3,29	7,28	3,32	7,27	3,35	7,25	3,38	7,24	3,41	7,22	3,44	7,21	3,48	
9	8,22	3,66	8,21	3,70	8,19	3,73	8,17	3,77	8,16	3,80	8,14	3,84	8,12	3,88	8,11	3,91	
10	9,14	4,07	9,12	4,11	9,10	4,15	9,08	4,19	9,06	4,23	9,05	4,27	9,03	4,31	9,01	4,35	
11	10,05	4,47	10,03	4,52	10,01	4,56	9,99	4,61	9,97	4,65	9,95	4,69	9,93	4,74	9,91	4,78	
12	10,96	4,88	10,94	4,93	10,92	4,98	10,90	5,02	10,88	5,07	10,85	5,12	10,83	5,17	10,81	5,21	
13	11,88	5,29	11,85	5,34	11,83	5,39	11,81	5,44	11,78	5,49	11,76	5,55	11,73	5,60	11,71	5,65	
14	12,79	5,69	12,76	5,75	12,74	5,81	12,71	5,86	12,69	5,92	12,66	5,97	12,64	6,03	12,61	6,08	
15	13,70	6,10	13,68	6,16	13,65	6,22	13,62	6,28	13,59	6,34	13,57	6,40	13,54	6,46	13,51	6,52	
16	14,62	6,51	14,59	6,57	14,56	6,64	14,53	6,70	14,50	6,76	14,47	6,83	14,44	6,89	14,41	6,95	
17	15,53	6,91	15,50	6,98	15,47	7,05	15,44	7,12	15,41	7,19	15,37	7,25	15,35	7,32	15,31	7,39	
18	16,44	7,32	16,41	7,39	16,38	7,47	16,35	7,54	16,31	7,61	16,28	7,68	16,25	7,75	16,21	7,82	
19	17,36	7,73	17,32	7,80	17,29	7,88	17,25	7,96	17,22	8,03	17,18	8,11	17,15	8,18	17,11	8,26	
20	18,27	8,14	18,24	8,21	18,20	8,29	18,16	8,37	18,13	8,45	18,09	8,53	18,05	8,61	18,01	8,69	
21	19,18	8,54	19,15	8,63	19,11	8,71	19,07	8,79	19,03	8,88	18,99	8,96	18,96	9,04	18,92	9,12	
22	20,10	8,95	20,06	9,04	20,02	9,12	19,98	9,21	19,94	9,30	19,90	9,39	19,86	9,47	19,82	9,56	
23	21,01	9,36	20,97	9,45	20,94	9,55	20,89	9,63	20,84	9,72	20,80	9,81	20,76	9,90	20,72	9,99	
24	21,93	9,76	21,88	9,86	21,85	9,96	21,80	10,05	21,75	10,14	21,71	10,24	21,66	10,33	21,62	10,43	
25	22,84	10,17	22,79	10,27	22,75	10,38	22,70	10,47	22,66	10,57	22,61	10,67	22,57	10,77	22,52	10,86	
26	23,75	10,58	23,71	10,68	23,66	10,79	23,61	10,89	23,56	10,99	23,51	11,09	23,47	11,20	23,42	11,30	
27	24,67	10,98	24,62	11,09	24,57	11,21	24,52	11,31	24,47	11,41	24,42	11,52	24,37	11,63	24,32	11,73	
28	25,58	11,39	25,53	11,50	25,48	11,62	25,43	11,73	25,37	11,84	25,32	11,95	25,28	12,06	25,22	12,17	
29	26,49	11,80	26,44	11,91	26,39	12,04	26,34	12,14	26,28	12,26	26,23	12,37	26,18	12,49	26,12	12,60	
30	27,41	12,20	27,35	12,32	27,30	12,44	27,24	12,56	27,19	12,68	27,13	12,80	27,08	12,92	27,02	13,03	
31	28,32	12,61	28,26	12,73	28,21	12,86	28,15	12,98	28,10	13,10	28,04	13,22	27,98	13,35	27,92	13,47	
32	29,23	13,02	29,18	13,14	29,12	13,27	29,06	13,40	29,00	13,53	28,94	13,65	28,88	13,78	28,82	13,90	
33	30,15	13,42	30,09	13,55	30,03	13,69	29,97	13,82	29,91	13,95	29,85	14,08	29,79	14,21	29,72	14,34	
34	31,06	13,83	31,00	13,97	30,94	14,10	30,88	14,24	30,81	14,37	30,75	14,51	30,69	14,64	30,62	14,77	
35	31,97	14,24	31,91	14,38	31,85	14,51	31,78	14,66	31,72	14,79	31,65	14,93	31,59	15,07	31,53	15,21	
36	32,89	14,64	32,82	14,79	32,76	14,93	32,69	15,07	32,63	15,22	32,56	15,36	32,50	15,50	32,43	15,64	
37	33,80	15,05	33,73	15,20	33,67	15,35	33,60	15,49	33,53	15,64	33,46	15,79	33,40	15,93	33,33	16,08	
38	34,72	15,46	34,65	15,61	34,58	15,76	34,51	15,91	34,44	16,06	34,37	16,21	34,30	16,36	34,23	16,51	
39	35,63	15,86	35,56	16,02	35,49	16,18	35,42	16,33	35,34	16,49	35,28	16,64	35,21	16,79	35,13	16,94	
40	36,54	16,27	36,47	16,43	36,40	16,59	36,33	16,75	36,25	16,91	36,18	17,07	36,10	17,22	36,03	17,38	
41	37,46	16,68	37,38	16,84	37,31	17,00	37,23	17,17	37,16	17,33	37,08	17,49	37,01	17,65	36,93	17,81	
42	38,37	17,08	38,29	17,25	38,22	17,42	38,14	17,58	38,06	17,75	37,99	17,92	37,92	18,08	37,83	18,25	
43	39,28	17,49	39,20	17,66	39,13	17,83	39,05	18,00	38,97	18,18	38,89	18,34	38,82	18,51	38,73	18,68	
44	40,20	17,90	40,12	18,07	40,04	18,25	39,96	18,42	39,88	18,60	39,79	18,77	39,72	18,94	39,63	19,12	
45	41,11	18,30	41,03	18,48	40,9	18,66	40,87	18,84	40,78	19,02	40,70	19,20	40,62	19,38	40,53	19,55	
46	42,02	18,71	41,94	18,89	41,86	19,08	41,77	19,26	41,69	19,45	41,60	19,63	41,52	19,81	41,43	19,99	
47	42,94	19,12	42,85	19,30	42,77	19,49	42,68	19,68	42,59	19,87	42,51	20,05	42,42	20,24	42,33	20,42	
48	43,85	19,52	43,76	19,72	43,68	19,91	43,59	20,10	43,50	20,29	43,41	20,48	43,32	20,67	43,23	20,85	
49	44,76	19,93	44,68	20,13	44,59	20,32	44,50	20,52	44,41	20,72	44,31	20,91	44,23	21,10	44,13	21,29	
50	45,68	20,34	45,59	20,54	45,50	20,74	45,41	20,93	45,32	21,13	45,22	21,33	45,14	21,53	45,04	21,72	
51	46,59	20,74	46,50	20,95	46,41	21,15	46,32	21,35	46,22	21,55	46,13	21,76	46,03	21,96	45,94	22,16	
52	47,51	21,15	47,41	21,36	47,32	21,57	47,22	21,77	47,13	21,98	47,03	22,18	46,94	22,39	46,84	22,59	
53	48,42	21,56	48,32	21,77	48,23	21,98	48,13	22,19	48,03	22,40	47,94	22,61	47,84	22,82	47,74	23,03	
54	49,33	21,96	49,23	22,18	49,14	22,40	49,04	22,61	48,95	22,82	48,84	23,04	48,74	23,25	48,64	23,46	
55	50,25	22,37	50,15	22,59	50,05	22,81	49,95	23,03	49,85	23,24	49,74	23,46	49,65	23,68	49,54	23,90	
56	51,16	22,78	51,06	23,00	50,96	23,23	50,86	23,45	50,75	23,67	50,65	23,89	50,55	24,11	0,44	24,33	
57	52,07	23,18	51,97	23,41	51,87	23,64	51,76	23,87	51,66	24,09	51,55	24,32	51,45	24,54	51,34	24,77	
58	52,98	23,59	52,88	23,82	52,78	24,06	52,68	24,29	52,56	24,52	52,45	24,75	52,35	24,97	52,24	25,20	
59	53,90	24,00	53,79	24,23	53,69	24,47	53,58	24,70	53,47	24,94	53,36	25,17	53,26	25,41	53,14	25,63	
60	54,81	24,40	54,71	24,64	54,60	24,88	54,49	25,12	54,38	25,36	54,27	25,59	54,16	25,83	54,04	26,07	
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	66 Deg.		65 Degrees								64 Degrees						

	24 Degrees						25 Degrees								
in.	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		Distance
Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
24,81	55,62	25,06	55,51	25,30	55,40	25,54	55,29	25,78	55,17	26,02	55,06	26,26	54,94	26,51	61
25,22	56,53	25,47	56,42	25,71	56,30	25,96	56,19	26,20	56,08	26,45	55,96	26,69	55,84	26,94	62
25,63	57,44	25,88	57,33	26,13	57,21	26,38	57,10	26,63	56,98	26,88	56,86	27,12	56,75	27,37	63
26,03	58,35	26,29	58,24	26,54	58,12	26,80	58,00	27,05	57,88	27,30	57,77	27,56	57,65	27,80	64
26,44	59,27	26,70	59,15	26,96	59,03	27,22	58,91	27,47	58,79	27,73	58,67	27,99	58,55	28,24	65
26,85	60,18	27,11	60,06	27,37	59,94	27,63	59,82	27,90	59,69	28,16	59,57	28,42	59,45	28,67	66
27,26	61,09	27,52	60,97	27,79	60,84	28,05	60,72	28,32	60,60	28,58	60,48	28,85	60,35	29,11	67
27,66	62,00	27,93	61,88	28,20	61,75	28,47	61,63	28,74	61,50	29,01	61,38	29,38	61,25	29,54	68
28,07	62,91	28,34	62,79	28,62	62,66	28,89	62,53	29,16	62,40	29,44	62,28	29,71	62,15	29,97	69
28,47	63,82	28,75	63,70	29,03	63,57	29,31	63,44	29,58	63,31	29,86	63,18	30,14	63,05	30,41	70
28,88	64,74	29,16	64,61	29,44	64,48	29,73	64,35	30,01	64,22	30,29	64,08	30,57	63,95	30,85	71
29,29	65,65	29,57	65,52	29,86	65,39	30,14	65,25	30,43	65,12	30,72	64,99	30,99	64,85	31,28	72
29,69	66,56	29,98	66,43	30,27	66,29	30,56	66,16	30,85	66,02	31,15	65,89	31,43	65,75	31,71	73
30,10	67,47	30,39	67,34	30,69	67,20	30,98	67,07	31,28	66,94	31,58	66,79	31,86	66,65	32,15	74
30,51	68,39	30,81	68,25	31,10	68,11	31,40	67,97	31,70	67,84	32,00	67,70	32,29	67,55	32,58	75
30,91	69,30	31,22	69,16	31,52	69,02	31,82	68,88	32,12	68,75	32,42	68,60	32,72	68,46	33,02	76
31,32	70,21	31,63	70,07	31,93	69,93	32,24	69,78	32,54	69,65	32,85	69,50	33,15	69,36	33,45	77
31,73	71,12	32,04	70,98	32,35	70,83	32,66	70,69	32,97	70,55	33,28	70,41	33,58	70,26	33,88	78
32,14	72,03	32,45	71,89	32,76	71,74	33,08	71,6	33,39	71,46	33,70	71,31	33,92	71,16	34,32	79
32,54	72,94	32,86	72,80	33,18	72,65	33,49	72,51	33,81	72,36	34,13	72,21	34,44	72,06	34,76	80
32,95	73,85	33,27	73,71	33,59	73,56	33,91	73,41	34,23	73,26	34,55	73,11	34,87	72,96	35,19	81
33,35	74,77	33,68	74,62	34,00	74,47	34,33	74,32	34,66	74,17	34,98	74,01	35,30	73,86	35,62	82
33,76	75,68	34,09	75,53	34,42	75,38	34,75	75,22	35,08	75,07	35,41	74,92	35,73	74,76	36,06	83
34,17	76,59	34,50	76,44	34,84	76,28	35,17	76,13	35,50	75,97	35,83	75,82	36,17	75,66	36,49	84
34,57	77,50	34,91	77,35	35,25	77,19	35,59	77,04	35,93	76,88	36,26	76,72	36,60	76,56	36,93	85
34,98	78,41	35,32	78,26	35,67	78,10	36,61	77,94	36,35	77,78	36,69	77,63	37,03	77,46	37,36	86
35,39	79,33	35,74	79,17	36,08	79,01	36,43	78,85	36,77	78,69	37,12	78,53	37,46	78,36	37,79	87
35,80	80,24	36,15	80,08	36,50	79,92	36,85	79,75	37,19	79,59	37,54	79,43	37,89	79,26	38,23	88
36,2	81,15	36,56	80,99	36,91	80,83	37,26	80,66	37,62	80,49	37,97	80,33	38,33	80,16	38,66	89
36,61	82,06	36,97	81,90	37,32	81,73	37,68	81,57	38,04	81,40	38,39	81,23	38,75	81,06	39,10	90
37,01	82,97	37,38	82,81	37,74	82,64	38,10	82,47	38,46	82,31	38,82	82,14	39,18	81,96	39,54	91
37,42	83,88	37,79	83,72	38,15	83,55	38,52	83,38	38,88	83,21	39,25	83,04	39,61	82,87	39,97	92
37,83	84,79	38,20	84,63	38,57	84,46	38,94	84,29	39,31	84,11	39,67	83,94	40,04	83,77	40,40	93
38,24	85,71	38,61	85,54	38,98	85,37	39,36	85,19	39,73	85,02	40,10	84,85	40,47	84,66	40,84	94
38,61	86,62	39,02	86,45	39,40	86,27	39,76	86,10	40,15	85,92	40,53	85,75	40,90	85,57	41,27	95
39,02	87,52	39,43	87,36	39,81	87,18	40,18	87,00	40,57	86,83	40,95	86,65	41,33	86,47	41,71	96
39,43	88,44	39,84	88,27	40,23	88,09	40,60	87,91	41,00	87,73	41,38	87,55	41,73	87,37	42,14	97
39,83	89,35	40,25	89,18	40,64	89,00	41,02	88,82	41,42	88,63	41,81	88,46	42,19	88,27	42,57	98
40,24	90,26	40,66	90,09	41,06	89,91	41,44	89,73	41,84	89,54	42,23	89,36	42,63	89,17	43,01	99
40,67	91,18	41,07	91,00	41,47	90,81	41,87	90,63	42,26	90,45	42,66	90,26	43,05	90,07	43,45	100
41,08	92,09	41,48	91,91	41,88	91,72	42,29	91,54	42,69	91,35	43,08	91,16	43,48	90,97	43,88	101
41,49	93,00	41,89	92,82	42,30	92,63	42,70	92,44	43,11	92,25	43,51	92,07	43,91	91,87	44,31	102
41,90	93,91	42,31	93,73	42,71	93,54	43,12	93,35	43,53	93,16	43,94	92,97	44,34	92,77	44,75	103
42,30	94,82	42,72	94,64	43,13	94,45	43,54	94,26	43,95	94,06	44,37	93,87	44,78	93,67	45,18	104
42,71	95,74	43,13	95,55	43,54	95,35	43,96	95,16	44,38	94,97	44,79	94,77	45,21	94,58	45,62	105
43,12	96,65	43,54	96,46	43,96	96,26	44,38	96,07	44,80	95,87	45,22	95,68	45,64	95,48	46,05	106
43,52	97,56	43,95	97,37	44,37	97,17	44,80	96,97	45,22	96,77	45,65	96,59	46,07	96,38	46,48	107
43,93	98,47	44,36	98,28	44,79	98,08	45,22	97,88	45,6	97,68	46,07	97,49	46,50	97,28	46,92	108
44,34	99,38	44,77	99,10	45,20	98,99	45,64	98,79	46,07	98,58	46,50	98,39	46,93	98,18	47,35	109
44,74	100,3	45,18	100,1	45,62	99,90	46,05	99,69	46,49	99,49	46,92	99,29	47,36	99,08	47,79	110
45,15	101,2	45,59	101,0	46,03	100,8	46,47	100,6	46,91	100,4	47,35	100,2	47,79	99,98	48,22	111
45,56	102,1	46,00	101,9	46,45	101,7	46,89	101,5	47,33	101,3	47,78	101,1	48,22	100,9	48,66	112
45,96	103,0	46,41	102,8	46,86	102,6	47,31	102,4	47,76	102,2	48,20	102,0	48,65	101,8	49,09	113
46,37	103,9	46,83	103,7	47,28	103,5	47,73	103,3	48,19	103,1	48,63	102,9	49,08	102,7	49,53	114
46,78	104,9	47,23	104,6	47,69	104,4	48,15	104,2	48,60	104,0	49,06	103,8	49,52	103,6	49,96	115
47,18	105,8	47,65	105,6	48,11	105,3	48,57	105,1	49,03	104,9	49,49	104,7	49,95	104,5	50,39	116
47,59	106,7	48,06	106,5	48,52	106,3	48,99	106,0	49,45	105,8	49,91	105,6	50,38	105,4	50,83	117
48,00	107,6	48,47	107,4	48,94	107,2	49,41	106,9	49,87	106,7	50,34	106,5	50,87	106,3	51,26	118
48,40	108,5	48,97	108,3	49,35	108,1	49,82	107,8	50,30	107,6	50,77	107,4	51,23	107,2	51,70	119
48,81	109,4	49,29	109,2	49,76	109,0	50,24	108,8	50,71	108,	51,19	108,3	51,67	108,1	52,13	120
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
in.	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
eg.	65 Degrees								64 Degrees						

Diſtance	26 Degrees								27 Degrees						
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
1	0,90	0,44	0,90	0,44	0,90	0,45	0,89	0,45	0,89	0,45	0,89	0,46	0,89	0,46	0,89
2	1,80	0,88	1,79	0,89	1,79	0,89	1,79	0,90	1,78	0,91	1,78	0,92	1,77	0,92	1,77
3	2,70	1,32	2,69	1,33	2,69	1,34	2,68	1,35	2,67	1,36	2,67	1,37	2,66	1,39	2,66
4	3,60	1,75	3,59	1,77	3,58	1,79	3,57	1,80	3,56	1,82	3,56	1,83	3,55	1,85	3,54
5	4,49	2,19	4,48	2,21	4,48	2,23	4,47	2,25	4,46	2,27	4,45	2,29	4,44	2,31	4,43
6	5,39	2,63	5,38	2,65	5,37	2,68	5,36	2,70	5,35	2,72	5,33	2,75	5,32	2,77	5,31
7	6,29	3,07	6,28	3,10	6,27	3,12	6,25	3,15	6,24	3,18	6,22	3,21	6,21	3,23	6,20
8	7,19	3,51	7,18	3,54	7,16	3,57	7,14	3,60	7,13	3,63	7,11	3,66	7,10	3,69	7,08
9	8,09	3,95	8,07	3,98	8,05	4,02	8,04	4,05	8,02	4,09	8,00	4,12	7,98	4,16	7,97
10	8,99	4,38	8,97	4,42	8,95	4,46	8,93	4,50	8,91	4,54	8,89	4,58	8,87	4,62	8,85
11	9,89	4,82	9,87	4,87	9,84	4,91	9,82	4,95	9,80	4,99	9,78	5,04	9,76	5,08	9,73
12	10,79	5,26	10,76	5,31	10,74	5,35	10,72	5,40	10,69	5,45	10,67	5,49	10,64	5,54	10,62
13	11,68	5,70	11,66	5,75	11,63	5,80	11,61	5,85	11,58	5,90	11,56	5,95	11,53	6,00	11,51
14	12,58	6,14	12,56	6,19	12,53	6,25	12,50	6,30	12,47	6,36	12,45	6,41	12,42	6,47	12,40
15	13,48	6,58	13,45	6,63	13,42	6,69	13,40	6,75	13,37	6,81	13,34	6,87	13,31	6,93	13,28
16	14,38	7,01	14,35	7,08	14,32	7,14	14,29	7,20	14,26	7,26	14,22	7,33	14,19	7,39	14,16
17	15,28	7,45	15,25	7,52	15,21	7,59	15,18	7,65	15,15	7,72	15,11	7,78	15,08	7,85	15,05
18	16,18	7,89	16,14	7,96	16,11	8,03	16,07	8,10	16,04	8,17	16,00	8,24	15,97	8,31	15,93
19	17,08	8,33	17,04	8,40	17,00	8,48	16,97	8,55	16,93	8,63	16,89	8,70	16,85	8,76	16,82
20	17,98	8,77	17,94	8,85	17,90	8,92	17,86	9,00	17,82	9,08	17,78	9,16	17,74	9,24	17,70
21	18,88	9,21	18,83	9,29	18,79	9,37	18,75	9,45	18,71	9,53	18,67	9,62	18,63	9,70	18,59
22	19,77	9,64	19,73	9,73	19,69	9,82	19,65	9,90	19,60	9,99	19,56	10,07	19,51	10,16	19,47
23	20,67	10,08	20,63	10,17	20,58	10,26	20,54	10,35	20,49	10,44	20,45	10,58	20,40	10,62	20,36
24	21,57	10,52	21,52	10,62	21,48	10,71	21,43	10,80	21,38	10,90	21,34	10,99	21,29	11,08	21,24
25	22,47	10,96	22,42	11,06	22,37	11,16	22,33	11,25	22,28	11,35	22,23	11,45	22,18	11,55	22,13
26	23,37	11,40	23,32	11,50	23,27	11,60	23,22	11,70	23,17	11,80	23,12	11,91	23,06	12,01	23,01
27	24,27	11,84	24,22	11,94	24,16	12,05	24,11	12,15	24,06	12,26	24,00	12,36	23,95	12,47	23,89
28	25,17	12,27	25,11	12,39	25,06	12,49	25,00	12,60	24,95	12,71	24,89	12,82	24,84	12,93	24,78
29	26,07	12,71	26,01	12,83	25,95	12,94	25,90	13,0	25,84	13,17	25,78	13,28	25,72	13,39	25,67
30	26,96	13,15	26,91	13,27	26,85	13,39	26,79	13,50	26,73	13,62	26,67	13,74	26,61	13,85	26,55
31	27,86	13,59	27,80	13,71	27,74	13,83	27,68	13,95	27,62	14,07	27,56	14,19	27,50	14,32	27,44
32	28,76	14,03	28,70	14,15	28,64	14,28	28,58	14,40	28,51	14,53	28,45	14,65	28,38	14,78	28,32
33	29,66	14,47	29,60	14,60	29,53	14,73	29,47	14,85	29,40	14,98	29,34	15,11	29,27	15,24	29,21
34	30,56	14,90	30,49	15,04	30,43	15,17	30,36	15,30	30,29	15,44	30,23	15,57	30,16	15,70	30,09
35	31,46	15,34	31,39	15,48	31,32	15,62	31,25	15,75	31,19	15,89	31,12	16,03	31,05	16,16	30,98
36	32,36	15,78	32,29	15,92	32,22	16,06	32,15	16,20	32,08	16,34	32,01	16,48	31,93	16,63	31,86
37	33,26	16,22	33,18	16,37	33,11	16,51	33,04	16,65	32,97	16,80	32,89	16,94	32,82	17,09	32,75
38	34,15	16,66	34,08	16,81	34,01	16,96	33,93	17,10	33,86	17,25	33,78	17,40	33,71	17,55	33,63
39	35,05	17,10	34,98	17,25	34,90	17,40	34,83	17,55	34,75	17,71	34,67	17,86	34,59	18,00	34,52
40	35,95	17,54	35,88	17,69	35,80	17,85	35,72	18,00	35,64	18,16	35,56	18,32	35,49	18,47	35,40
41	36,85	17,97	36,77	18,13	36,69	18,29	36,61	18,45	36,53	18,61	36,45	18,77	36,37	18,93	36,29
42	37,75	18,41	37,67	18,58	37,59	18,74	37,51	18,90	37,42	19,07	37,34	19,23	37,25	19,39	37,17
43	38,65	18,85	38,57	19,02	38,48	19,19	38,40	19,35	38,31	19,52	38,23	19,69	38,14	19,86	38,06
44	39,55	19,29	39,46	19,46	39,38	19,63	39,29	19,80	39,20	19,98	39,12	20,15	39,03	20,32	38,94
45	40,44	19,73	40,36	19,90	40,27	20,08	40,18	20,26	40,10	20,43	40,01	20,61	39,92	20,78	39,83
46	41,35	20,17	41,26	20,35	41,17	20,53	41,08	20,71	40,99	20,88	40,90	21,06	40,80	21,24	40,71
47	42,24	20,60	42,15	20,79	42,06	20,97	41,97	21,16	41,88	21,34	41,78	21,52	41,69	21,70	41,60
48	43,14	21,04	43,05	21,23	42,96	21,42	42,86	21,61	42,77	21,79	42,67	21,98	42,58	22,16	42,48
49	44,04	21,48	43,95	21,67	43,85	21,86	43,76	22,06	43,66	22,25	43,56	22,44	43,46	22,63	43,37
50	44,94	21,92	44,84	22,12	44,75	22,31	44,65	22,51	44,55	22,70	44,45	22,89	44,35	23,09	44,25
51	45,84	22,36	45,74	22,56	45,64	22,76	45,54	22,96	45,44	23,15	45,35	23,35	45,25	23,55	45,14
52	46,74	22,80	46,64	23,00	46,54	23,20	46,44	23,41	46,33	23,61	46,23	23,81	46,14	24,01	46,02
53	47,64	23,23	47,53	23,44	47,43	23,65	47,32	23,86	47,22	24,06	47,12	24,27	47,03	24,47	46,91
54	48,54	23,67	48,43	23,88	48,33	24,10	48,21	24,31	48,12	24,52	48,01	24,73	47,91	24,94	47,79
55	49,43	24,11	49,33	24,33	49,22	24,54	49,11	24,76	49,01	24,97	48,90	25,19	48,79	25,40	48,68
56	50,33	24,55	50,23	24,77	50,12	24,99	50,00	25,21	49,90	25,42	49,78	25,64	49,68	25,86	49,56
57	51,23	24,99	51,12	25,21	51,01	25,43	50,89	25,66	50,79	25,88	50,67	26,10	50,57	26,32	50,45
58	52,13	25,43	52,02	25,65	51,91	25,88	51,78	26,11	51,68	26,33	51,56	26,56	51,45	26,78	51,33
59	53,03	25,86	52,92	26,10	52,80	26,33	52,68	26,56	52,57	26,79	52,45	27,02	52,33	27,25	52,22
60	53,93	26,30	53,81	26,54	53,70	26,77	53,57	27,01	53,46	27,24	53,34	27,47	53,22	27,71	53,10
Diſtance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15
	64 Deg.		63 Degrees								62 Degrees				

	26 Degrees						27 Degrees								Diſtance
n.	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
ep	Lat.	Dep	Lat.	Dep.	Lat	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
6,74	54,71	26,98	54,59	27,22	54,47	27,46	54,35	27,69	54,23	27,93	54,11	28,17	53,98	28,40	61
7,18	55,61	27,42	55,49	27,66	55,37	27,91	55,24	28,15	55,12	28,39	55,00	28,63	54,87	28,87	62
7,62	56,50	27,86	56,38	28,11	56,25	28,36	56,13	28,60	56,02	28,85	55,88	29,09	55,75	29,34	63
,05	57,40	28,31	57,28	28,56	57,15	28,81	57,03	29,06	56,90	29,30	56,77	29,55	56,64	29,80	64
,49	58,30	28,75	58,17	29,00	58,01	29,26	57,92	29,51	57,79	29,76	57,66	30,02	57,52	30,27	65
,93	59,19	29,19	59,07	29,45	58,94	29,71	58,81	29,96	58,68	30,22	58,54	30,48	58,41	30,73	66
,37	60,09	29,63	59,96	29,89	59,83	30,76	59,70	30,42	59,56	30,68	59,43	30,94	59,29	31,20	67
,81	60,99	30,07	60,86	30,34	60,72	30,61	60,59	30,87	60,45	31,14	60,32	31,40	60,18	31,67	68
,24	61,89	30,52	61,75	30,79	61,62	31,06	61,48	31,33	61,34	31,59	61,20	31,86	61,06	32,13	69
,69	62,78	30,96	62,65	31,23	62,51	31,51	62,37	31,78	62,23	32,06	62,09	32,32	61,95	32,59	70
,12	63,68	31,40	63,54	31,68	63,40	31,96	63,26	32,23	63,12	32,51	62,98	32,79	62,83	33,06	71
,56	64,58	31,84	64,44	32,13	64,30	32,41	64,15	32,69	64,01	32,97	63,87	33,25	63,72	33,53	72
,00	65,47	32,29	65,33	32,57	65,19	32,86	65,04	33,14	64,90	33,43	64,75	33,71	64,60	33,99	73
,44	66,37	32,73	66,23	33,02	66,08	33,31	65,94	33,60	65,79	33,88	65,64	34,17	65,49	34,46	74
,88	67,27	33,17	67,12	33,46	66,97	33,76	66,83	34,05	66,68	34,34	66,53	34,63	66,37	34,92	75
,31	68,17	33,61	68,02	33,91	67,87	34,21	67,72	34,50	67,57	34,80	67,41	35,10	67,26	35,39	76
,75	69,06	34,05	68,91	34,36	68,77	34,66	68,61	34,96	68,45	35,26	68,30	35,56	68,14	35,86	77
,19	69,96	34,50	69,81	34,80	69,65	35,11	69,50	35,41	69,34	35,72	69,19	36,02	69,03	36,32	78
,63	70,86	34,94	70,70	35,25	70,55	35,56	70,39	35,87	70,23	36,17	70,07	36,48	69,91	36,79	79
,07	71,75	35,38	71,59	35,70	71,44	36,01	71,28	36,32	71,12	36,63	70,96	36,94	70,80	37,25	80
,51	72,65	35,83	72,49	36,14	72,33	36,46	72,17	36,77	72,01	37,09	71,85	37,40	71,68	37,72	81
,95	73,54	36,27	73,38	36,59	73,22	36,91	73,06	37,23	72,90	37,55	72,74	37,86	72,57	38,18	82
,38	74,44	36,71	74,28	37,03	74,12	37,36	73,95	37,68	73,79	38,00	73,62	38,33	73,46	38,65	83
,82	75,34	37,15	75,17	37,48	75,01	37,81	74,85	38,14	74,68	38,46	74,51	38,79	74,34	39,11	84
,26	76,24	37,59	76,07	37,93	75,90	38,26	75,74	38,59	75,57	38,92	75,40	39,25	75,23	39,58	85
,70	77,13	38,04	76,96	38,37	76,80	38,71	76,63	39,04	76,46	39,38	76,28	39,71	76,11	40,05	86
,14	78,03	38,48	77,86	38,82	77,69	39,16	77,52	39,50	77,35	39,84	77,17	40,17	77,00	40,51	87
,57	78,93	38,92	78,75	39,26	78,58	39,61	78,41	39,95	78,23	40,29	78,06	40,64	77,88	40,98	88
,01	79,82	39,36	79,65	39,71	79,48	40,06	79,30	40,41	79,13	40,75	78,94	41,10	78,77	41,44	89
,45	80,72	39,81	80,54	44,16	80,37	40,51	80,19	40,86	80,01	41,21	79,83	41,56	79,65	41,91	90
,89	81,62	40,25	81,44	40,60	81,26	40,96	81,08	41,31	80,90	41,67	80,72	42,02	80,53	42,37	91
,33	82,51	40,70	82,33	41,05	82,15	41,41	81,91	41,77	81,79	42,12	81,61	42,48	81,42	42,84	92
,77	83,41	41,13	83,23	41,50	83,05	41,86	82,80	42,22	82,68	42,58	82,49	42,94	82,30	43,30	93
,21	84,31	41,57	84,12	41,94	83,94	42,31	83,70	42,68	83,57	43,04	83,38	43,41	83,19	43,77	94
,64	85,20	42,02	85,02	42,39	84,85	42,76	84,59	43,13	84,46	43,50	84,27	43,87	84,07	44,24	95
,08	86,10	42,46	85,91	42,83	85,73	43,21	85,48	43,59	85,35	43,96	85,15	44,33	84,96	44,70	96
,52	87,00	42,90	86,81	43,28	86,62	43,66	86,37	44,04	86,24	44,41	86,04	44,79	85,84	45,17	97
,96	87,89	43,34	87,70	43,73	87,52	44,11	87,26	44,49	87,12	44,87	86,93	45,25	86,73	45,63	98
,40	88,79	43,78	88,60	44,17	88,41	44,56	88,15	44,95	88,01	45,33	87,81	45,72	87,61	46,10	99
,84	89,69	44,23	89,49	44,62	89,30	45,01	89,10	45,40	88,90	45,79	88,70	46,18	88,50	46,56	100
,28	90,58	44,67	90,39	45,07	90,19	45,46	89,99	45,85	89,79	46,25	89,59	46,64	89,38	47,03	101
,71	91,48	45,11	91,28	45,51	91,08	45,91	90,88	46,31	90,68	46,70	90,48	47,10	90,27	47,49	102
,15	92,38	45,56	92,18	45,96	91,98	46,36	91,77	46,76	91,57	47,16	91,36	47,56	91,15	47,96	103
,59	93,28	46,00	93,07	46,40	92,87	46,81	92,67	47,22	92,46	47,60	92,25	48,02	92,04	48,43	104
,03	94,17	46,44	93,97	46,85	93,76	47,26	93,56	47,68	93,35	48,06	93,14	48,49	92,92	48,89	105
,47	95,07	46,88	94,86	47,30	94,66	47,71	94,45	48,12	94,24	48,54	94,02	48,95	93,81	49,36	106
,90	95,97	47,32	95,76	47,74	95,55	48,16	95,34	48,59	95,13	48,99	94,91	49,41	94,69	49,82	107
,34	96,86	47,77	96,65	48,19	96,44	48,61	96,23	49,04	96,01	49,45	95,80	49,87	95,58	50,29	108
,78	97,77	48,21	97,55	48,63	97,34	49,06	97,12	49,49	96,90	49,91	96,68	50,33	96,46	50,76	109
,22	98,66	48,65	98,44	49,08	98,23	49,51	98,01	49,94	97,79	50,37	97,57	50,79	97,35	51,22	110
,65	99,55	49,09	99,34	49,53	99,12	49,96	98,91	50,39	98,68	50,82	98,46	51,26	98,23	51,68	111
,10	100,5	49,54	100,2	49,97	100,0	50,41	99,80	50,85	99,57	51,28	99,35	51,72	99,12	52,15	112
54	101,3	49,98	101,0	50,42	100,9	50,86	100,7	51,30	100,4	51,74	100,2	52,18	100,0	52,68	113
97	102,2	50,42	101,9	50,87	101,8	51,31	101,6	51,76	101,3	52,20	101,1	52,64	100,9	53,08	114
41	103,1	50,86	102,8	51,31	102,7	51,76	102,5	52,21	102,2	52,66	102,0	53,10	101,8	53,55	115
85	104,0	51,30	103,7	51,76	103,6	52,21	103,4	52,66	103,1	53,11	102,9	53,57	102,7	54,01	116
28	104,9	51,75	104,6	52,20	104,5	52,66	104,2	53,12	104,0	53,57	103,8	54,03	103,5	54,49	117
72	105,8	52,19	105,5	52,65	105,4	53,11	105,0	53,57	104,9	54,03	104,7	54,49	104,4	54,95	118
16	106,7	52,63	106,4	53,10	106,3	53,56	105,0	54,63	105,8	54,49	105,6	54,95	105,3	55,41	119
60	107,6	53,08	107,4	53,54	107,2	54,01	106,9	54,48	106,7	54,94	106,4	55,41	106,1	55,87	120
t.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Diſtance
	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	63 Degrees								62 Degrees						

Distance	28 Degrees								29 Degrees						
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 M
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
1	0,88	0,47	0,88	0,47	0,88	0,48	0,88	0,48	0,88	0,49	0,87	0,49	0,87	0,49	0,87
2	1,77	0,94	1,76	0,95	1,76	0,95	1,75	0,96	1,75	0,97	1,75	1,00	1,74	0,99	1,74
3	2,65	1,41	2,64	1,42	2,64	1,43	2,63	1,44	2,62	1,46	2,62	1,47	2,61	1,48	2,61
4	3,53	1,88	3,52	1,89	3,52	1,91	3,51	1,92	3,50	1,94	3,49	1,96	3,48	1,97	3,47
5	4,42	2,35	4,40	2,37	4,39	2,39	4,38	2,41	4,37	2,43	4,36	2,45	4,35	2,46	4,34
6	5,30	2,82	5,29	2,84	5,27	2,86	5,26	2,89	5,25	2,91	5,25	2,93	5,22	2,96	5,21
7	6,18	3,29	6,17	3,31	6,15	3,34	6,14	3,37	6,12	3,40	6,11	3,42	6,09	3,45	6,08
8	7,06	3,76	7,05	3,79	7,03	3,82	7,01	3,85	6,99	3,88	6,98	3,91	6,96	3,94	6,95
9	7,95	4,23	7,93	4,27	7,91	4,29	7,89	4,33	7,87	4,37	7,85	4,40	7,83	4,43	7,81
10	8,83	4,70	8,81	4,73	8,79	4,77	8,77	4,81	8,75	4,85	8,73	4,89	8,70	4,92	8,68
11	9,71	5,16	9,69	5,21	9,67	5,25	9,64	5,29	9,62	5,33	9,60	5,38	9,57	5,42	9,55
12	10,60	5,63	10,57	5,68	10,55	5,73	10,52	5,77	10,50	5,82	10,47	5,86	10,44	5,9	10,42
13	11,48	6,10	11,45	6,15	11,42	6,2	11,40	6,25	11,37	6,30	11,34	6,35	11,31	6,40	11,29
14	12,36	6,57	12,33	6,63	12,30	6,68	12,28	6,73	12,25	6,79	12,22	6,84	12,18	6,89	12,15
15	13,24	7,04	13,21	7,10	13,18	7,16	13,15	7,22	13,12	7,27	13,09	7,33	13,05	7,39	13,02
16	14,13	7,51	14,10	7,57	14,06	7,63	14,03	7,70	14,00	7,76	13,96	7,82	13,92	7,88	13,99
17	15,01	7,98	14,98	8,05	14,94	8,11	14,91	8,18	14,87	8,24	14,84	8,31	14,79	8,37	14,86
18	15,89	8,45	15,86	8,52	15,82	8,59	15,79	8,66	15,75	8,73	15,71	8,80	15,66	8,86	15,63
19	16,78	8,92	16,74	8,99	16,70	9,07	16,66	9,14	16,62	9,21	16,58	9,29	16,53	9,35	16,49
20	17,66	9,39	17,62	9,46	17,58	9,54	17,54	9,62	17,49	9,70	17,45	9,77	17,41	9,85	17,36
21	18,54	9,86	18,50	9,94	18,46	10,02	18,41	10,10	18,37	10,18	18,32	10,26	18,28	10,34	18,23
22	19,43	10,33	19,38	10,41	19,33	10,50	19,29	10,58	19,24	10,67	19,20	10,75	19,15	10,83	19,10
23	20,31	10,80	20,26	10,89	20,21	10,97	20,17	11,06	20,12	11,15	20,07	11,24	20,02	11,32	19,97
24	21,19	11,27	21,14	11,36	21,09	11,45	21,04	11,54	20,99	11,64	20,94	11,73	20,89	11,82	20,81
25	22,07	11,73	22,02	11,83	21,97	11,93	21,92	12,03	21,87	12,12	21,82	12,22	21,76	12,31	21,70
26	22,96	12,20	22,90	12,30	22,85	12,41	22,79	12,51	22,74	12,61	22,69	12,7	22,63	12,81	22,57
27	23,84	12,67	23,79	12,78	23,73	12,88	23,67	12,99	23,62	13,09	23,57	13,20	23,50	13,29	23,44
28	24,72	13,14	24,67	13,25	24,61	13,36	24,55	13,47	24,49	13,58	24,43	13,68	24,37	13,78	24,31
29	25,61	13,61	25,55	13,72	25,49	13,83	25,43	13,95	25,37	14,06	25,31	14,17	25,24	14,28	25,18
30	26,49	14,08	26,43	14,2	26,37	14,32	26,30	14,43	26,24	14,54	26,18	14,66	26,11	14,77	26,05
31	27,37	14,55	27,31	14,67	27,14	14,79	27,18	14,91	27,11	15,03	27,05	15,15	26,98	15,27	26,91
32	28,26	15,02	28,19	15,14	28,02	15,27	28,06	15,39	27,99	15,51	27,92	15,64	27,85	15,76	27,78
33	29,14	15,49	29,07	15,62	28,90	15,75	28,93	15,87	28,86	16,00	28,80	16,13	28,72	16,25	28,65
34	30,02	15,96	29,95	16,09	29,78	16,22	29,81	16,35	29,74	16,48	29,67	16,61	29,59	16,74	29,52
35	30,90	16,43	30,83	16,57	30,66	16,70	30,69	16,84	30,61	16,96	30,54	17,10	30,46	17,23	30,39
36	31,79	16,90	31,71	17,04	31,54	17,18	31,56	17,32	31,49	17,45	31,42	17,59	31,33	17,73	31,25
37	32,67	17,37	32,59	17,51	32,42	17,65	32,44	17,80	32,36	17,94	32,29	18,08	32,20	18,22	32,12
38	33,55	17,84	33,48	17,98	33,30	18,13	33,32	18,28	33,24	18,42	33,16	18,57	33,07	18,71	32,99
39	34,44	18,31	34,36	18,46	34,18	18,61	34,20	18,76	34,11	18,99	34,03	19,06	33,94	19,20	33,86
40	35,32	18,78	35,24	18,93	35,15	19,09	35,07	19,24	35,00	19,39	34,9	19,54	34,81	19,70	34,73
41	36,20	19,2	36,12	19,41	36,03	19,56	35,95	19,72	35,85	19,88	35,77	20,03	35,68	20,19	35,60
42	37,08	19,72	37,00	19,88	36,91	20,04	36,82	20,20	36,73	20,36	36,65	20,52	36,55	20,68	36,46
43	37,79	20,19	37,88	20,35	37,79	20,52	37,7	20,68	37,60	20,85	37,52	21,01	37,42	21,17	37,33
44	38,85	20,66	38,76	20,83	38,67	20,99	38,58	21,16	38,48	21,33	38,39	21,50	38,29	21,67	38,20
45	39,73	21,12	39,64	21,30	39,55	21,47	39,45	21,65	39,35	21,82	39,27	21,99	39,16	22,16	39,07
46	40,65	21,59	40,52	21,77	40,43	21,95	40,33	22,13	40,23	22,30	40,14	22,48	40,03	22,65	39,94
47	41,60	22,06	41,40	22,24	41,31	22,43	41,21	22,61	41,10	22,80	41,01	22,97	40,90	23,14	40,80
48	42,41	22,53	42,28	22,72	42, 9	22,90	42,09	23,09	42,00	23,28	41,88	23,46	41,77	23,63	41,67
49	43,30	23,00	43,17	23,19	43,06	23,3	42,96	23,57	42,85	23,77	42,76	23,95	42,64	24,13	42,54
50	44,15	23,4	44,05	23,67	43,94	23,86	43,84	24,05	43,73	24,24	43,63	24,43	43,52	24,62	43,41
51	45,03	23,94	44,93	24,14	44,82	24,34	44,71	24,53	44,61	24,73	44,50	24,93	44,39	25,11	44,28
52	45,91	24,41	45,81	24,61	45,70	24,81	45,59	25,01	45,48	25,61	45,37	25,42	45,26	25,61	45,15
53	46,80	24,88	46,69	25,09	46,58	25,29	46,47	25,49	46,36	25,70	46,24	25,91	46,13	26,10	46,01
54	47,68	25,35	47,57	25,56	47,46	25,77	47,35	25,97	47,23	26,18	47,12	26,40	47,00	26,59	46,88
55	48,56	25,82	48,45	26,03	48,34	26,24	48,22	26,46	48,11	26,67	47,99	26,89	47,87	27,08	47,75
56	49,45	26,29	49,33	26,50	49,22	26,72	49,10	26,94	48,90	27,15	48,86	27,37	48,74	27,57	48,62
57	50,33	26,7	50,21	26,97	50,09	27,20	49,98	27,42	49,86	27,64	49,74	27,86	49,61	28,07	49,49
58	51,21	27,23	51,09	27,46	50,97	27,67	50,85	27,90	50,73	28,12	50,61	28,35	50,48	28,56	50,35
59	52,10	27,70	51,97	27,92	51,85	28,1	51,78	28,38	51,67	28,61	51,48	28,84	51,35	29,05	51,22
60	52,98	28,17	52,85	28,40	52,73	28,63	52,60	28,86	52,48	29,09	52,35	29,32	52,22	29,55	52,09
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 M
	62 Deg.		61 Degrees								60 Degrees				

28 Degrees							29 Degrees								
Min.	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		Distance
Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
28,64	53,73	28,87	53,61	29,11	53,48	29,34	53,35	29,57	53,22	29,81	53,09	30,04	52,96	30,27	61
29,11	54,62	29,35	54,49	29,58	54,36	29,82	54,23	30,06	54,10	30,29	53,96	30,53	53,83	30,77	62
29,58	55,50	29,82	55,37	30,06	55,24	30,30	55,10	30,54	54,97	30,78	54,83	31,02	54,70	31,26	63
30,04	56,38	30,29	56,25	30,54	56,11	30,78	55,98	31,03	55,84	31,27	55,70	31,51	55,56	31,76	64
30,51	57,26	30,76	57,12	31,02	56,99	31,26	56,85	31,51	56,72	31,76	56,57	32,01	56,43	32,25	65
30,98	58,14	31,24	57,90	31,49	57,87	31,75	57,73	32,00	57,59	32,25	57,44	32,50	57,30	32,75	66
31,45	59,02	31,70	58,78	31,97	58,74	32,23	58,60	32,48	58,46	32,74	58,31	32,99	58,17	33,25	67
31,92	59,90	32,18	59,66	32,05	59,62	32,71	59,48	32,97	59,33	33,23	59,18	33,48	59,04	33,74	68
32,39	60,78	32,66	60,54	32,52	60,50	33,19	60,35	33,46	60,21	33,72	60,05	33,97	59,90	34,24	69
32,86	61,66	33,13	61,52	33,40	61,37	33,67	61,22	33,94	61,08	34,20	60,93	34,41	60,77	34,74	70
33,33	62,54	33,61	62,40	33,88	62,25	34,1	62,09	34,42	61,95	34,69	61,80	34,96	61,64	35,23	71
33,80	63,42	34,08	63,28	34,36	63,13	34,63	62,97	34,91	62,82	35,18	62,67	35,45	62,51	35,73	72
34,27	64,31	34,55	64,15	34,83	64,00	35,11	63,85	35,39	63,69	35,67	63,54	35,95	63,38	36,22	73
34,74	65,19	35,02	65,03	35,31	64,88	35,59	64,72	35,88	64,57	36,16	64,41	36,44	64,25	36,72	74
35,21	66,07	35,50	65,91	35,79	65,76	36,07	65, 9	36,36	65,44	36,6	65,28	36,93	65,11	37,22	75
35,68	66,95	35,97	66,79	36,26	56,63	36,56	60,47	36,85	66,31	37,14	66,15	37,42	65,98	37,71	76
36,15	67,83	36,44	67, 7	36,74	67,51	37,04	67,35	37,33	67,19	37,63	67,02	37,9	66,85	38,21	77
36,62	68,71	36,92	68,55	37,22	68,39	37, 2	68,22	37,82	68,06	38, 1	67,89	38,41	67,72	38,70	78
37,08	69,59	37,39	69,43	37,69	69,26	38,00	69,09	38,30	68,93	38,60	68,76	38,90	68,59	39,20	79
37,56	70,47	37,87	70,31	38,17	70,14	38,48	69,97	38,78	69,80	39,09	69,63	39,39	69,4	39,70	80
38,03	71,35	38,34	71,19	38,65	71,02	38,96	70,85	39,2	70,67	39,58	70,50	39,89	70,32	40,29	81
38,50	72,23	38,81	72,06	39,13	71,89	39,44	71,71	39,7	71,55	40,07	71,37	40,38	71,19	40,69	82
38,97	73,11	39,29	72,94	39,61	72,77	39,92	72,59	40,24	72,42	40,56	72,24	40,87	72,06	41,19	83
39,43	74,00	39,76	73,82	40,08	73,65	40,4	73,46	40,72	73,39	41,04	73,11	41,36	72,93	41,68	84
39,90	74,88	40,23	74,70	40,56	74,52	40,88	74,34	41,21	74,17	41,53	73,98	41,8	73,80	42,18	85
40,37	75,76	40,70	75,58	41,04	75,40	41,37	75,21	41,70	75,04	42,02	74,85	42,3	74,66	42,67	86
40,84	76,64	41,18	76,46	41,51	76,28	41,85	76,09	42,18	75,91	42,51	75,72	42,84	75,53	43,17	87
41,31	77,52	41,65	77,34	41,99	77,1	42,33	76,96	42,67	76,78	43,00	76,59	43,33	76,40	43,67	88
41,78	78,40	42,12	78,22	42,47	78,03	42,81	77,84	43,1	77,65	43,49	77,46	43,82	77,27	44,16	89
42,25	79,28	42,60	79,09	42,94	78,91	43,29	78,72	43,63	78,53	43,97	78,33	44,32	78,14	44,66	90
42,72	80,16	43,07	79,97	43,42	79,78	43,77	79,59	44,12	79,40	44,46	79,20	44,81	79,01	45,16	91
43,19	81,04	43,55	80,85	43,90	80,66	44,25	80,47	44,60	80,27	44,95	80,07	45,30	79,87	45,65	92
43,66	81,92	44,02	81,73	44,38	81,54	44,73	81,34	45,09	81,14	45,44	80,94	45,79	80,74	46,15	93
44,13	82,8	44,49	82,61	44,85	82,41	45,21	82,22	45,57	82,02	45,93	81,81	46,29	81,61	46,64	94
44,60	83,69	44,96	83,49	45,33	83,29	45,69	83,09	46,66	82,89	46,42	82,68	46,78	82,48	47,14	95
45,07	84,57	45,44	84,37	45,81	84,17	46,18	83,97	46,54	83,76	46,91	83,55	47,27	83,35	47,64	96
45,54	85,45	45,91	85,25	46,28	85,05	46,66	84,84	47,03	84,64	47,40	84,42	47,76	84,21	48,13	97
46,00	86,33	46,38	86,13	46,76	85,92	47,14	85,72	47,51	85,51	47,89	85,29	48,25	85,08	48,63	98
46,47	87,21	46,86	87,01	47,24	86,80	47,62	86,59	48,00	86,38	48,38	86,16	48,75	85,95	49,12	99
46,95	88,09	47,33	87,88	47,72	87,67	48,1	87,46	48,48	87,25	48,86	87,04	49,24	86,82	49,62	100
47,42	88,97	47,81	88,76	48,19	88,55	48,58	88,34	48,97	88,12	49,35	87,91	49,73	87,69	50,12	101
47,89	89,85	48,28	89,65	48,67	89,43	49,06	89,21	49,45	89,00	49,84	88,78	50,23	88,56	50,61	102
48,35	90,73	48,75	90,52	49,15	90,30	49,54	90,09	49,94	89,87	50,33	89,65	50,72	89,42	51,11	103
48,82	91,61	49,22	91,40	49,62	91,18	50,02	90,96	50,42	90,74	50,82	90,52	51,21	90,29	51,61	104
49,29	92,49	49,70	92,28	50,10	92,06	50,50	91,84	50,91	91,63	51,31	91,39	51,70	91,1	52,10	105
49,76	93,38	50,17	93,16	50,58	92,94	50,99	92,71	51,09	92,49	51,80	92,26	52,19	92,03	52,60	106
50,23	94,26	50,64	94,04	51,06	93,81	51,47	93,59	51,88	93,36	52,28	93,13	52,69	92,90	53,09	107
50,70	95,14	51,12	94,91	51,53	94,69	51,95	94,46	52,96	94,24	52,77	94,00	53,18	93,76	33,59	108
51,17	96,02	51,59	95,79	52,01	95,57	52,43	95,34	52,45	95,11	53,26	94,87	53,67	94,65	54,09	109
51,64	96,90	52,07	96,67	52,49	96,44	52,91	96,21	53,33	95,98	53,75	95,74	54,17	95,50	54,58	110
52,11	97,78	52,54	97,55	52,97	97,32	53,39	97,08	53,81	96,85	54,24	96,61	54,66	96,37	55,08	111
52,58	98,66	53,01	98,43	53,44	98,19	53,87	97,96	54,30	97,72	54,73	97,48	55,15	97,24	55,58	112
53,05	99,54	53,48	99,31	53,92	99,07	54,35	98,83	54,78	98,59	55,17	98,35	55,64	98,11	56,07	113
53,52	100,4	53,96	100,2	54,40	99,95	54,83	99,71	55,27	99,47	55,66	99,22	56,13	98,97	56,57	114
53,99	101,3	54,43	101,1	54,47	00,8	55,31	100,6	55,75	100,3	56,15	100,1	56,63	99,84	57,06	115
54,46	102,2	54,90	101,9	55,35	101,7	35,80	101,5	56,24	101,2	56,64	101,0	57,12	100,	57,56	116
54,93	103,1	55,38	102,8	55,83	102,6	56,28	102,3	56,72	102,1	57,13	101,8	57,61	101,6	58,06	117
55,09	103,9	55,85	103,7	56,30	103,5	56,76	103,2	57,21	103,0	57,62	102,7	58,10	102,4	58,55	118
55,56	104,8	56,32	104,6	56,78	104,3	57,24	104,1	57,69	103,8	58,11	103,6	58,59	103,3	59,05	119
56,34	105,7	56,80	105,5	57,26	105,2	57,72	105,0	51,18	104,7	58,64	104,4	59,09	104,2	50,55	120
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
in.	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min		15 Min.		
eg.	61 Degrees								60 Degrees						

Distance	30 Degrees								31 Degrees							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Dep.	Lat.	De
1	0,87	0,50	0,86	0,50	0,86	0,51	0,86	0,51	0,86	0,51	0,85	0,52	0,85	0,52	0,85	0,
2	1,73	1,00	1,73	1,00	1,72	1,01	1,72	1,02	1,71	1,03	1,71	1,04	1,70	1,04	1,70	1,
3	2,60	1,50	2,59	1,51	2,58	1,52	2,58	1,53	2,57	1,54	2,56	1,56	2,56	1,57	2,55	1,
4	3,46	2,00	3,45	2,01	3,45	2,03	3,44	2,04	3,43	2,06	3,42	2,07	3,41	2,09	3,40	2,
5	4,33	2,50	4,32	2,52	4,31	2,54	4,28	2,56	4,29	2,57	4,27	2,59	4,26	2,61	4,25	2,
6	5,2	3,00	5,18	3,02	5,17	3,04	5,16	3,07	5,14	3,09	5,13	3,11	5,12	3,13	5,10	3,
7	6,06	3,50	6,05	3,53	6,03	3,55	6,02	3,58	6,00	3,60	5,98	3,63	5,97	3,66	5,95	3,
8	6,93	4,00	6,91	4,03	6,89	4,06	6,88	4,09	6,86	4,12	6,84	4,15	6,82	4,18	6,80	4,
9	7,79	4,50	7,77	4,53	7,75	4,57	7,73	4,60	7,71	4,63	7,69	4,67	7,67	4,70	7,65	4,
10	8,66	5,00	8,64	5,04	8,62	5,07	8,59	5,11	8,57	5,15	8,55	5,19	8,53	5,22	8,50	5,
11	9,53	5,50	9,50	5,54	9,48	5,58	9,45	5,62	9,43	5,66	9,40	5,71	9,38	5,75	9,35	5,
12	10,39	6,00	10,35	6,04	10,34	6,09	10,31	6,13	10,29	6,18	10,26	6,22	10,23	6,27	10,20	6,
13	11,26	6,50	11,23	6,55	11,20	6,60	11,17	6,65	11,14	6,69	11,11	6,74	11,08	6,79	11,05	6,
14	12,12	7,00	12,09	7,05	12,06	7,10	12,03	7,16	12,00	7,21	11,97	7,26	11,94	7,32	11,90	7,
15	12,99	7,50	12,96	7,56	12,93	7,61	12,89	7,67	12,86	7,72	12,82	7,78	12,79	7,84	12,75	7,
16	13,86	8,00	13,82	8,06	13,79	8,12	13,75	8,18	13,71	8,24	13,68	8,30	13,04	8,36	13,60	8,
17	14,72	8,50	14,69	8,56	14,65	8,63	14,61	8,69	14,57	8,75	14,53	8,82	14,50	8,88	14,45	8,
18	15,59	9,00	15,55	9,07	15,51	9,14	15,47	9,20	15,43	9,27	15,39	9,34	15,35	9,41	15,30	9,
19	16,45	9,50	16,41	9,57	16,37	9,65	16,33	9,71	16,28	9,78	16,24	9,86	16,20	9,93	16,15	10,
20	17,32	10,00	17,28	10,07	17,23	10,15	17,19	10,23	17,14	10,30	17,10	10,37	17,05	10,45	17,01	10,
21	18,19	10,50	18,14	10,58	18,09	10,66	18,05	10,74	18,00	10,82	17,95	10,89	17,91	10,97	17,86	11,
22	19,05	11,0	19,00	11,08	18,96	11,17	18,91	11,25	18,86	11,33	18,81	11,41	18,76	11,50	18,71	11,
23	19,92	11,50	19,87	11,59	19,82	11,67	19,76	11,76	19,71	11,85	19,66	11,93	19,61	12,02	19,56	12,
24	20,78	12,00	20,73	12,09	20,68	12,18	20,62	12,27	20,57	12,36	20,52	12,45	20,46	12,54	20,41	12,
25	21,65	12,50	21,60	12,59	21,54	12,69	21,48	12,78	21,43	12,88	21,37	12,97	21,32	13,06	21,26	13,
26	22,52	13,00	22,46	13,10	22,40	13,20	22,34	13,29	22,28	13,39	22,23	13,49	22,17	13,59	22,11	13,
27	23,38	13,50	23,32	13,60	23,27	13,71	23,20	13,80	23,14	13,91	23,08	14,01	23,02	14,11	22,96	14,
28	24,25	14,00	24,19	14,11	24,13	14,21	24,06	14,31	24,00	14,42	23,94	14,53	23,88	14,63	23,81	14,
29	25,11	14,50	25,05	14,61	24,99	14,72	24,92	14,82	24,86	14,94	24,79	15,05	24,73	15,16	24,66	15,
30	25,98	15,00	25,91	15,11	25,85	15,22	25,78	15,34	25,71	15,45	25,65	15,56	25,58	15,67	25,51	15,
31	26,85	15,50	26,78	15,62	26,71	15,73	26,64	15,85	26,57	15,97	26,50	16,08	26,43	16,20	26,36	16,
32	27,71	16,00	27,64	16,12	27,57	16,24	27,50	16,36	27,43	16,48	27,36	16,60	27,28	16,72	27,21	16,
33	28,58	16,50	28,51	16,62	28,43	16,75	28,36	16,87	28,29	17,00	28,21	17,12	28,14	17,24	28,06	17,
34	29,44	17,00	29,37	17,13	29,30	17,26	29,22	17,38	29,14	17,51	29,07	17,64	28,99	17,77	28,91	17,
35	30,31	17,50	30,23	17,63	30,16	17,77	30,08	17,89	30,00	18,03	29,92	18,16	29,84	18,29	29,76	18,
36	31,18	18,00	31,10	18,14	31,02	18,27	30,94	18,40	30,86	18,54	30,78	18,68	30,70	18,81	30,61	18,
37	32,04	18,50	31,96	18,64	31,88	18,78	31,79	18,92	31,71	19,06	31,63	19,20	31,55	19,34	31,46	19,
38	32,91	19,00	32,83	19,14	32,74	19,29	32,65	19,43	32,57	19,57	32,49	19,71	32,40	19,86	32,31	19,
39	33,77	19,50	33,69	19,65	33,60	19,80	33,51	19,94	33,43	20,09	33,34	20,23	33,26	20,38	33,16	20,
40	34,64	20,00	34,55	20,15	34,40	20,30	34,38	20,45	34,29	20,60	34,20	20,75	34,11	20,90	34,01	21,
41	35,51	20,50	35,42	20,65	35,33	20,81	35,23	20,96	35,14	21,12	35,05	21,27	34,96	21,42	34,86	21,
42	36,37	21,00	36,28	21,16	36,19	21,32	36,09	21,47	36,00	21,63	35,92	21,79	35,81	21,95	35,71	22,
43	37,24	21,50	37,15	21,66	37,05	21,83	36,95	21,98	36,86	22,15	36,76	22,31	36,66	22,47	36,56	22,
44	38,10	22,00	38,01	22,17	37,91	22,33	37,81	22,48	37,71	22,66	37,62	22,83	37,52	22,99	37,41	23,
45	38,97	22,50	38,87	22,67	38,77	22,84	38,67	22,99	38,57	23,18	38,47	23,35	38,37	23,51	38,26	23,
46	39,84	23,00	39,74	23,17	39,64	23,35	39,53	23,50	39,43	23,69	39,33	23,86	39,22	24,04	39,11	24,
47	40,70	23,50	40,60	23,68	40,50	23,86	40,39	24,01	40,29	24,21	40,18	24,38	40,08	24,56	39,96	24,
48	41,57	24,00	41,47	24,18	41,36	24,36	41,25	24,52	41,14	24,72	41,04	24,90	40,93	25,08	40,81	2
49	42,43	24,50	42,33	24,69	42,22	24,86	42,11	25,03	42,00	25,24	41,89	25,42	41,78	25,61	41,66	25,
50	43,30	25,00	43,19	25,19	43,08	25,36	42,97	25,56	42,86	25,75	42,75	25,94	42,64	26,12	42,52	26,
51	44,16	25,50	44,06	25,69	43,94	25,88	43,83	26,08	43,72	26,27	43,60	26,46	43,48	26,65	43,37	26,
52	45,03	26,0	44,92	26,20	44,81	26,39	44,69	26,59	44,57	26,77	44,46	26,98	44,34	27,17	44,22	27,
53	45,90	26,50	45,78	26,70	45,67	26,90	45,55	27,10	45,45	27,29	45,31	27,50	45,19	27,69	45,07	27,
54	46,76	27,00	46,65	27,20	46,53	27,41	46,41	27,61	46,29	27,80	46,17	28,01	46,04	28,22	45,92	28,
55	47,63	27,50	47,51	27,71	47,39	27,92	47,27	28,12	47,14	28,32	47,02	28,53	46,90	28,74	46,77	28,
56	48,50	28,00	48,38	28,21	48,25	28,42	48,13	28,63	48,00	28,85	47,88	29,05	47,75	29,26	47,62	29,
57	49,36	28,50	49,24	28,72	49,12	28,93	48,98	29,14	48,86	29,35	48,73	29,57	48,60	29,79	48,47	29,
58	50,23	29,00	50,10	29,22	49,98	29,44	49,84	29,65	49,71	29,86	49,59	30,09	49,46	30,31	49,32	30,
59	51,10	29,50	50,97	29,72	50,84	29,95	50,70	30,17	50,57	30,38	50,44	30,61	50,31	30,83	50,17	31,
60	51,96	30,00	51,83	30,23	51,70	30,45	51,56	30,68	51,43	30,90	51,29	31,13	51,16	31,35	51,02	31,
Distance	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	La
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min	
	60 Deg.		59 Degrees						58 Degrees							

30 Degrees								31 Degrees								Distance
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
at.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
,83	30,50	52,69	30,73	52,56	30,96	52,42	31,19	52,29	31,42	52,15	31,64	52,01	31,87	51,87	32,10	61
,69	31,00	53,56	31,23	53,42	31,47	53,28	31,70	53,14	31,93	53,00	32,16	52,86	32,40	52,72	32,62	62
,56	31,50	54,42	31,74	54,28	31,98	54,14	32,21	54,00	32,45	53,86	32,68	53,72	32,92	53,57	33,15	63
,43	32,00	55,29	32,24	55,15	32,48	55,00	32,72	54,86	32,96	54,71	33,20	54,57	33,44	54,42	33,68	64
,29	32,50	56,15	32,75	56,01	32,99	55,86	33,23	55,71	33,48	55,57	33,72	55,42	33,96	55,27	34,20	65
16	33,00	57,01	33,25	56,87	33,50	56,72	33,74	56,57	33,99	56,42	34,24	56,28	34,49	56,12	34,73	66
02	33,50	57,88	33,75	57,73	34,01	57,58	34,25	57,43	34,51	57,28	34,76	57,13	35,01	56,97	35,25	67
89	34,00	58,74	34,26	58,59	34,52	58,44	34,76	58,29	35,02	58,13	35,28	57,98	35,53	57,82	35,78	68
76	34,50	59,61	34,76	59,46	35,02	59,30	35,28	59,14	35,54	58,99	35,80	58,83	36,06	58,67	36,31	69
62	35,00	60,47	35,26	60,31	35,53	60,16	35,79	60,00	36,05	59,84	36,31	59,68	36,57	59,52	36,83	70
49	35,50	61,33	35,77	61,18	36,04	61,02	36,30	60,86	36,57	60,70	36,83	60,54	37,09	60,37	37,36	71
35	36,00	62,20	36,27	62,04	36,54	61,88	36,81	61,72	37,08	61,55	37,35	61,39	37,62	61,22	37,89	72
22	36,50	63,06	36,78	62,90	37,05	62,74	37,32	62,57	37,60	62,41	37,87	62,24	38,14	62,07	38,41	73
09	37,00	63,92	37,28	63,76	37,56	63,59	37,83	63,42	38,11	63,26	38,39	63,10	38,67	62,92	38,94	74
95	37,50	64,79	37,78	64,62	38,07	64,45	38,34	64,28	38,63	64,12	38,91	63,95	39,19	63,77	39,46	75
82	38,00	65,65	38,29	65,49	38,58	65,31	38,86	65,13	39,14	64,97	39,43	64,82	39,71	64,62	39,99	76
68	38,50	66,52	38,79	66,35	39,08	66,17	39,37	65,99	39,66	65,83	39,95	65,66	40,23	65,47	40,52	77
55	39,00	67,38	39,30	67,21	39,59	67,03	39,88	66,86	40,17	66,68	40,47	66,51	40,76	66,32	41,04	78
42	39,50	68,24	39,80	68,07	40,10	67,89	40,39	67,70	40,69	67,54	40,92	67,36	41,28	67,17	41,57	79
8	40,00	69,11	40,30	68,93	40,60	68,75	40,90	68,57	41,20	68,39	41,50	68,21	41,80	68,03	42,10	80
15	40,50	69,97	40,81	69,79	41,11	69,61	41,41	69,43	41,72	69,25	42,02	69,06	42,32	68,88	42,62	81
01	41,00	70,83	41,31	70,65	41,62	70,47	41,92	70,29	42,23	70,10	42,54	69,92	42,85	69,73	43,15	82
8	41,50	71,70	41,81	71,52	42,13	71,33	42,44	71,14	42,75	70,96	43,06	70,77	43,37	70,58	43,67	83
5	42,00	72,56	42,32	72,38	42,63	72,19	42,95	72,00	43,26	71,81	43,58	71,62	43,89	71,43	44,20	84
1	42,50	73,43	42,82	73,24	43,14	73,05	43,46	72,86	43,78	72,67	44,10	72,48	44,41	72,28	44,73	85
8	43,00	74,29	43,32	74,10	43,65	73,91	43,97	73,72	44,29	73,52	44,62	73,33	44,94	73,13	45,25	86
4	43,50	75,15	43,83	74,96	44,16	74,77	44,48	74,57	44,81	74,38	45,13	74,18	45,46	73,98	45,78	87
1	44,00	76,02	44,33	75,83	44,67	75,62	44,99	75,43	45,32	75,23	45,65	75,03	45,98	74,83	46,30	88
8	44,50	76,88	44,84	76,69	45,17	76,48	45,50	76,29	45,84	76,09	46,17	75,89	46,51	75,68	46,83	89
4	45,00	77,75	45,34	77,55	45,68	77,35	46,02	77,14	46,35	76,94	46,69	76,74	47,02	76,53	47,36	90
1	45,50	78,61	45,84	78,41	46,19	78,21	46,53	78,00	46,87	77,80	47,21	77,59	47,55	77,38	47,88	91
7	46,00	79,47	46,3	79,27	46,69	79,06	47,04	78,86	47,38	78,65	47,73	78,44	48,07	78,23	48,41	92
4	46,50	80,34	46,85	80,13	47,20	79,92	47,55	79,72	47,90	79,51	48,24	79,30	48,59	79,08	48,94	93
1	47,00	81,20	47,35	80,99	47,71	80,78	48,06	80,57	48,41	80,36	48,76	80,15	49,12	79,93	49,46	94
7	47,50	82,07	47,86	81,86	48,22	81,64	48,57	81,43	48,93	81,22	49,28	81,01	49,64	80,78	49,99	95
4	48,00	82,93	48,36	82,73	48,73	82,50	49,08	82,29	49,44	82,07	49,80	81,86	50,16	81,63	50,52	96
0	48,50	83,79	48,87	83,58	49,23	83,36	49,59	83,14	49,96	82,93	50,32	82,71	50,69	82,48	51,04	97
7	49,00	84,66	49,37	84,44	49,74	84,22	50,10	84,00	50,47	83,78	50,84	83,57	51,21	83,33	51,57	98
4	49,50	85,52	49,87	85,29	50,25	85,08	50,61	84,86	50,99	84,64	51,36	84,42	51,73	84,18	52,09	99
0	50,00	86,38	50,38	86,16	50,75	85,94	51,13	85,72	51,50	85,49	51,88	85,26	52,25	85,03	52,62	100
	50,50	87,25	50,88	87,02	51,26	86,80	51,64	86,57	52,02	86,35	52,40	86,12	52,77	85,88	53,15	101
3	51,00	88,11	51,38	87,89	51,77	87,66	52,15	87,43	52,53	87,20	52,91	86,97	53,30	86,73	53,67	102
0	51,50	88,90	51,89	88,75	52,28	88,52	52,66	88,29	53,05	88,06	53,43	87,82	53,82	87,58	54,20	103
7	52,00	89,84	52,30	89,61	52,79	89,38	53,17	89,14	53,56	88,91	53,95	88,68	54,34	88,43	54,72	104
3	52,50	90,70	52,90	90,47	53,29	90,24	53,68	90,00	54,08	89,77	54,47	89,53	54,87	89,28	55,25	105
0	53,00	91,57	53,40	91,33	53,80	91,09	54,19	90,86	54,59	90,62	54,99	90,38	55,39	90,13	55,78	106
6	53,50	92,43	53,90	92,20	54,31	91,95	54,71	91,72	55,11	91,48	55,51	91,23	55,9	90,98	56,30	107
3	54,00	93,30	54,41	93,06	54,82	92,81	55,22	92,57	55,62	92,33	56,03	92,09	56,43	91,83	56,83	108
0	54,50	94,16	54,91	93,92	55,33	93,67	55,73	93,43	56,14	93,19	56,55	92,94	56,96	92,68	57,35	109
6	55,00	95,02	55,41	94,78	55,83	94,53	56,24	94,29	56,65	94,04	57,06	93,79	57,47	93,54	57,88	110
3	55,50	95,89	55,92	95,64	56,34	95,39	56,7	95,15	57,18	94,89	57,58	94,64	58,00	94,39	58,41	111
9	56,00	96,75	56,42	96,50	56,84	96,2	57,26	96,00	57,68	95,75	58,10	95,50	58,52	95,24	58,93	112
5	56,50	97,61	56,93	97,36	57,35	97,11	57,77	96,86	58,20	96,60	58,62	96,35	59,04	96,09	59,46	113
3	57,00	98,48	57,43	98,23	57,86	97,97	58,29	97,72	58,71	97,46	59,14	97,20	59,57	96,94	59,99	114
9	57,50	99,34	57,93	99,09	58,37	98,83	58,80	98,57	59,23	98,31	59,66	98,05	60,09	97,79	60,51	115
5	58,00	100,2	58,44	99,95	58,88	99,69	59,31	99,43	59,74	99,17	60,18	98,91	60,61	98,64	61,04	116
3	58,50	101,1	58,94	100,8	59,38	100,5	59,82	100,3	60,26	100,0	60,70	99,76	61,14	99,49	61,56	117
2	59,00	101,9	59,45	101,7	59,89	101,4	60,33	101,1	60,77	100,8	61,22	100,6	61,66	100,3	62,09	118
1	59,50	102,8	59,95	102,5	60,40	102,3	60,84	102,0	61,29	101,7	61,74	101,5	62,18	101,2	62,62	119
	60,00	103,7	60,45	103,4	60,90	103,1	61,35	102,9	61,80	102,6	62,25	102,3	62,70	102,0	63,14	120
De	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Distance
Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
Deg.		59 Degrees								58 Degrees						

Distance	32 Degrees								33 Degrees							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep
1	0,85	0,53	0,85	0,53	0,84	0,54	0,84	0,54	0,84	0,54	0,84	0,55	0,83	0,55	0,83	0,5
2	1,70	1,06	1,69	1,07	1,69	1,07	1,68	1,08	1,68	1,09	1,67	1,10	1,67	1,10	1,66	1,1
3	2,54	1,59	2,54	1,60	2,53	1,61	2,52	1,62	2,52	1,63	2,51	1,64	2,50	1,66	2,49	1,6
4	3,39	2,12	3,38	2,13	3,37	2,15	3,36	2,16	3,35	2,18	3,34	2,19	3,34	2,21	3,33	2,2
5	4,24	2,65	4,23	2,67	4,22	2,69	4,20	2,70	4,19	2,72	4,18	2,74	4,17	2,76	4,16	2,7
6	5,09	3,18	5,07	3,20	5,06	3,22	5,05	3,25	5,03	3,27	5,02	3,29	5,00	3,31	4,99	3,3
7	5,94	3,71	5,92	3,73	5,90	3,76	5,89	3,79	5,87	3,81	5,85	3,84	5,84	3,86	5,82	3,8
8	6,78	4,24	6,77	4,27	6,75	4,30	6,73	4,33	6,71	4,36	6,69	4,39	6,67	4,42	6,65	4,4
9	7,63	4,77	7,61	4,80	7,59	4,84	7,57	4,87	7,55	4,90	7,53	4,93	7,50	4,97	7,48	5,0
10	8,48	5,30	8,46	5,34	8,43	5,37	8,41	5,41	8,39	5,45	8,38	5,48	8,34	5,52	8,32	5,5
11	9,33	5,83	9,30	5,87	9,27	5,91	9,25	5,95	9,22	5,99	9,20	6,03	9,17	6,07	9,15	6,1
12	10,18	6,36	10,15	6,40	10,12	6,45	10,09	6,49	10,06	6,54	10,03	6,58	10,01	6,62	9,98	6,6
13	11,02	6,89	10,99	6,94	10,96	6,98	10,91	7,03	10,90	7,08	10,87	7,13	10,84	7,17	10,81	7,2
14	11,87	7,42	11,84	7,47	11,81	7,52	11,75	7,57	11,74	7,63	11,71	7,67	11,67	7,73	11,64	7,7
15	12,72	7,95	12,69	8,00	12,65	8,06	12,59	8,11	12,58	8,17	12,54	8,22	12,51	8,28	12,47	8,3
16	13,57	8,48	13,53	8,60	13,49	8,60	13,44	8,65	13,42	8,72	13,38	8,77	13,34	8,83	13,30	8,8
17	14,42	9,01	14,38	9,07	14,34	9,13	14,28	9,19	14,26	9,26	14,21	9,32	14,18	9,38	14,13	9,4
18	15,26	9,54	15,22	9,67	15,18	9,67	15,12	9,73	15,10	9,81	15,05	9,87	15,01	9,93	14,96	9,9
19	16,11	10,07	16,07	10,24	16,02	10,21	15,96	10,27	15,94	10,35	15,89	10,41	15,84	10,49	15,80	10,5
20	16,96	10,60	16,91	10,67	16,87	10,75	16,82	10,82	16,77	10,89	16,73	10,97	16,68	11,04	16,63	11,1
21	17,81	11,13	17,76	11,21	17,71	11,28	17,66	11,36	17,61	11,44	17,56	11,51	17,51	11,59	17,46	11,6
22	18,65	11,66	18,61	11,74	18,55	11,82	18,50	11,90	18,45	11,98	18,40	12,06	18,35	12,14	18,29	12,2
23	19,50	12,19	19,45	12,27	19,40	12,36	19,34	12,44	19,29	12,53	19,23	12,61	19,18	12,69	19,12	12,7
24	20,35	12,72	20,30	12,81	20,24	12,90	20,18	12,98	20,13	13,07	20,07	13,16	20,01	13,25	19,95	13,3
25	21,20	13,25	21,14	13,34	21,08	13,44	21,03	13,52	20,97	13,62	20,91	13,71	20,85	13,80	20,78	13,8
26	22,05	13,78	21,99	13,88	21,93	13,97	21,87	14,06	21,81	14,16	21,74	14,25	21,68	14,35	21,62	14,4
27	22,90	14,31	22,84	14,41	22,77	14,51	22,61	14,61	22,65	14,71	22,58	14,80	22,52	14,90	22,45	15,0
28	23,74	14,84	23,68	14,94	23,62	15,05	23,45	15,15	23,48	15,25	23,41	15,35	23,35	15,45	23,28	15,5
29	24,59	15,37	24,53	15,48	24,45	15,58	24,39	15,69	24,32	15,80	24,25	15,90	24,18	16,01	24,11	16,1
30	25,44	15,90	25,37	16,01	25,30	16,12	25,23	16,23	25,16	16,34	25,09	16,45	25,02	16,56	24,94	16,6
31	26,29	16,43	26,22	16,54	26,14	16,66	26,07	16,77	26,00	16,88	25,92	17,00	25,85	17,11	25,78	17,2
32	27,14	16,96	27,06	17,08	26,99	17,19	26,91	17,31	26,84	17,43	26,76	17,54	26,68	17,66	26,61	17,7
33	27,99	17,49	27,91	17,61	27,83	17,73	27,75	17,85	27,68	17,97	27,60	18,09	27,52	18,21	27,44	18,3
34	28,83	18,02	28,76	18,14	28,67	18,27	28,59	18,39	28,52	18,52	28,43	18,64	28,35	18,77	28,27	18,8
35	29,68	18,55	29,60	18,68	29,52	18,80	29,44	18,93	29,35	19,06	29,27	19,19	29,19	19,32	29,10	19,4
36	30,53	19,08	30,45	19,21	30,36	19,34	30,28	19,47	30,19	19,61	30,10	19,74	30,02	19,87	29,93	20,0
37	31,38	19,61	31,29	19,75	31,20	19,88	31,12	20,02	31,03	20,15	30,94	20,28	30,85	20,42	30,76	20,5
38	32,23	20,14	32,14	20,28	32,05	20,41	31,96	20,56	31,87	20,70	31,78	20,83	31,69	20,97	31,59	21,1
39	33,07	20,67	32,99	20,81	32,89	20,95	32,80	21,10	32,71	21,24	32,61	21,38	32,52	21,53	32,42	21,6
40	33,92	21,20	33,83	21,34	33,76	21,49	33,64	21,64	33,55	21,79	33,45	21,93	33,36	22,08	33,26	22,2
41	34,77	21,73	34,67	21,88	34,58	22,03	34,48	22,18	34,39	22,33	34,29	22,48	34,19	22,63	34,09	22,7
42	35,62	22,26	35,52	22,41	35,42	22,57	35,32	22,72	35,22	21,88	35,12	23,03	35,02	23,18	34,92	23,3
43	36,47	22,79	36,37	22,95	36,26	23,10	36,16	23,26	36,06	23,42	35,96	23,58	35,86	23,73	35,75	23,8
44	37,31	23,32	37,21	23,48	37,11	23,64	37,01	23,80	36,90	23,97	36,80	24,12	36,69	24,29	36,58	24,4
45	38,16	23,85	38,06	24,01	37,95	24,18	37,85	24,34	37,74	24,51	37,63	24,67	37,53	24,84	37,41	25,0
46	39,01	24,38	38,90	24,55	38,79	24,71	38,69	24,88	38,58	25,00	38,47	25,22	38,36	25,39	38,25	25,5
47	39,86	24,91	39,75	25,08	39,64	25,25	39,53	25,43	39,42	25,60	39,30	25,77	39,19	25,94	39,08	26,1
48	40,71	25,44	40,60	25,62	40,48	25,79	40,37	25,97	40,26	26,15	40,14	26,32	40,03	26,49	39,91	26,6
49	41,55	25,97	41,44	26,15	41,32	26,32	41,21	26,51	41,10	26,69	40,98	26,86	40,86	27,05	40,74	27,2
50	42,40	26,50	42,29	26,68	42,17	26,80	42,05	27,05	41,93	27,23	41,81	27,41	41,69	27,60	41,57	27,7
51	43,25	27,03	43,13	27,21	43,01	27,40	42,89	27,59	42,77	27,80	42,65	27,96	42,53	28,15	42,41	28,3
52	44,10	27,56	43,98	27,75	43,86	27,94	43,73	28,13	43,61	28,34	43,49	28,51	43,36	28,70	43,24	28,8
53	44,95	28,09	44,82	28,28	44,70	28,48	44,57	28,67	44,45	28,89	44,32	29,06	44,20	29,25	44,07	29,4
54	45,79	28,62	45,67	28,82	45,54	29,01	45,42	29,21	45,29	29,43	45,16	29,61	45,03	29,80	44,90	30,0
55	46,64	29,15	46,52	29,35	46,38	29,55	46,26	29,75	46,13	29,98	45,99	30,15	45,86	30,36	45,73	30,5
56	47,49	29,68	47,36	29,88	47,23	30,09	47,10	30,29	46,97	30,52	46,83	30,70	46,70	30,91	46,56	31,1
57	48,34	30,21	48,21	30,42	48,07	30,63	47,94	30,84	47,81	31,07	47,67	31,25	47,53	31,46	47,39	31,6
58	49,19	30,74	49,05	30,95	48,91	31,16	48,78	31,38	48,65	31,61	48,50	31,80	48,37	32,01	48,22	32,2
59	50,03	31,27	49,90	31,49	49,76	31,70	49,62	31,92	49,48	32,16	49,34	32,35	49,20	32,56	49,05	32,7
60	50,88	31,79	50,74	32,02	50,60	32,24	50,46	32,46	50,32	32,68	50,18	32,90	50,03	33,12	49,89	33,3
Distance	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.	
	58 Deg.		57 Degrees								56 Degrees					

32 Degrees							33 Degrees								Distance
Min.	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
32,32	51,59	32,55	51,45	32,77	51,30	33,00	51,16	33,22	51,01	33,44	50,87	33,67	50,72	33,89	61
32,85	52,44	33,08	52,29	33,31	52,14	33,54	52,00	33,77	51,85	33,98	51,70	34,22	51,55	34,45	62
33,38	53,28	33,62	53,13	33,85	52,98	34,08	52,84	34,31	52,68	34,53	52,53	34,77	52,38	35,00	63
33,91	54,13	34,15	53,97	34,39	53,83	34,62	53,68	34,86	53,52	35,08	53,37	35,32	53,21	35,56	64
34,44	54,97	34,69	54,82	34,92	54,67	35,16	54,51	35,4	54,36	35,63	54,20	35,88	54,04	36,11	65
34,97	55,82	35,22	55,66	35,46	55,51	35,71	55,35	35,95	55,19	36,17	55,04	36,43	54,87	36,67	66
35,50	56,67	35,75	56,50	35,99	56,35	36,25	56,19	36,50	56,03	36,72	55,87	36,98	55,71	37,23	67
36,03	57,51	36,29	57,35	36,53	57,19	36,79	57,03	37,04	56,86	37,27	56,70	37,53	56,54	37,78	68
36,56	58,36	36,82	58,19	37,07	58,03	37,33	57,87	37,58	57,70	37,82	57,54	38,08	57,37	38,34	69
37,09	59,20	37,35	59,04	37,61	58,87	37,87	58,71	38,12	58,54	38,38	58,37	38,64	58,20	38,89	70
37,62	60,05	37,89	59,88	38,15	59,71	38,41	59,55	38,67	59,38	38,93	59,21	39,19	59,03	39,45	71
38,15	60,89	38,42	60,72	38,68	60,55	38,95	60,38	39,21	60,21	39,48	60,04	39,74	59,87	40,00	72
38,68	61,74	38,95	61,57	39,22	61,40	39,19	61,22	39,76	61,05	40,02	60,87	40,29	60,70	40,56	73
39,21	62,58	39,49	62,41	39,76	62,24	40,03	62,06	40,30	61,88	40,57	61,71	40,84	61,53	41,11	74
39,74	63,43	40,02	63,25	40,30	63,08	40,57	62,90	40,85	62,72	41,12	62,54	41,40	62,38	41,67	75
40,27	64,28	40,56	64,09	40,83	63,92	41,11	63,74	41,40	63,56	41,67	63,38	41,95	63,21	42,23	76
40,80	65,12	41,09	64,94	41,37	64,76	41,65	64,58	41,94	64,39	42,22	64,21	42,50	64,04	42,78	77
41,33	65,97	41,62	65,78	41,91	65,60	42,20	65,42	42,48	65,23	42,76	65,04	43,05	64,87	43,34	78
41,86	66,81	42,16	66,62	42,44	66,44	42,74	66,26	43,03	66,06	43,33	65,88	43,60	65,70	43,89	79
42,39	67,66	42,69	67,47	42,98	67,28	43,28	67,09	43,57	66,90	43,86	66,71	44,15	66,52	44,45	80
42,92	68,50	43,22	68,31	43,52	68,12	43,82	67,93	44,12	67,74	44,41	67,54	44,71	67,35	45,00	81
43,45	69,35	43,76	69,16	44,06	68,96	44,36	68,77	44,66	68,57	44,96	68,38	45,26	68,18	45,56	82
43,98	70,20	44,29	70,00	44,59	69,81	44,90	69,61	45,21	69,41	45,51	69,21	45,81	69,01	46,11	83
44,15	71,04	44,82	70,84	45,13	70,65	45,44	70,45	45,75	70,25	46,05	70,05	46,36	69,84	46,67	84
45,04	71,89	45,36	71,69	45,67	71,53	45,98	71,29	46,30	71,08	46,60	70,88	46,91	70,67	47,23	85
45,57	72,73	45,69	72,53	46,21	72,37	46,52	72,12	46,84	71,92	47,15	71,77	47,47	71,50	47,78	86
46,10	73,58	46,43	73,37	46,74	73,21	47,06	72,96	47,39	72,85	47,70	72,55	48,02	72,34	48,34	87
46,63	74,43	46,96	74,21	47,28	74,05	47,61	73,80	47,93	73,69	48,25	73,38	48,57	73,17	48,89	88
47,16	75,27	47,49	75,06	47,82	74,89	48,15	74,64	48,48	74,53	48,79	74,22	49,12	73,99	49,55	89
47,69	76,12	48,02	75,90	48,36	75,69	48,69	75,48	49,02	75,27	49,35	75,05	49,67	74,83	50,00	90
48,22	76,95	48,56	76,75	48,89	76,53	49,23	76,32	49,56	76,10	49,89	75,88	50,22	75,66	50,56	91
48,75	77,86	49,09	77,59	49,43	77,38	49,77	77,16	50,11	76,94	50,44	76,72	50,78	76,49	51,11	92
49,28	78,65	49,63	78,43	49,97	78,22	50,31	78,00	50,65	77,77	50,99	77,55	51,33	77,33	51,67	93
49,81	79,40	50,16	79,28	50,50	79,06	50,85	78,84	51,20	78,61	51,54	78,39	51,88	78,18	52,22	94
50,34	80,35	50,69	80,12	51,04	79,90	51,39	79,67	51,74	79,45	52,09	79,22	52,43	79,01	52,78	95
50,87	81,19	51,23	80,96	51,58	80,74	51,93	80,51	52,39	80,28	52,63	80,05	52,99	79,84	53,34	96
51,40	82,04	51,76	81,81	52,12	81,58	52,47	81,35	52,83	81,12	53,18	80,89	53,54	80,67	53,89	97
51,93	82,88	52,30	82,65	52,65	82,42	53,01	82,19	53,38	81,95	53,73	81,72	54,09	81,50	54,45	98
52,46	83,73	52,83	83,49	53,19	83,26	53,56	83,03	53,92	82,79	54,28	82,56	54,64	82,33	55,00	99
52,99	84,57	53,36	84,34	53,73	84,10	54,09	83,87	54,46	83,63	54,83	83,39	55,19	83,15	55,56	100
53,52	85,42	53,89	85,18	54,27	84,94	54,64	84,71	55,01	84,46	55,38	84,22	55,75	84,00	56,11	101
54,05	86,26	54,43	86,02	54,80	85,79	55,18	85,54	55,55	85,30	55,92	85,06	56,30	84,83	56,67	102
54,58	87,11	54,96	86,87	55,34	86,63	55,72	86,38	56,10	86,14	56,47	85,89	56,85	85,66	57,22	103
55,11	87,96	55,49	87,70	55,88	87,47	56,26	87,22	56,64	86,97	57,02	86,72	57,40	86,49	57,78	104
55,64	88,80	56,03	88,55	36,41	88,31	56,80	88,06	57,19	87,86	57,57	87,56	57,95	87,34	58,34	105
56,17	89,65	56,56	89,40	56,95	89,15	57,34	88,90	57,73	88,64	58,12	88,39	58,51	88,17	58,89	106
56,70	90,49	57,10	90,24	57,49	89,99	57,88	89,74	58,28	89,48	58,66	89,23	59,06	89,00	59,45	107
57,23	91,34	57,63	91,08	58,03	90,83	58,42	90,58	58,82	90,32	59,21	90,06	59,61	89,84	60,00	108
57,76	92,19	58,16	91,93	58,56	91,67	58,97	91,42	39,37	91,15	59,76	90,89	60,16	90,69	60,56	109
58,29	93,03	58,17	92,77	59,10	92,51	59,51	92,25	59,91	91,99	60,31	91,73	60,77	91,46	61,11	110
58,82	93,88	59,23	93,62	59,64	93,35	60,05	93,09	60,45	92,83	60,86	92,56	61,26	92,29	61,67	111
59,35	94,72	59,76	94,46	60,18	94,20	60,59	93,93	61,00	93,66	61,41	93,40	61,82	93,12	62,22	112
59,88	95,56	60,30	95,30	60,71	95,04	61,13	94,77	61,54	94,50	61,96	94,23	62,37	93,96	62,78	113
60,41	96,41	60,83	96,14	61,25	95,88	61,67	95,63	62,09	95,34	62,50	95,06	62,92	94,79	63,34	114
60,94	97,25	61,37	96,99	61,79	96,72	62,21	96,45	62,63	96,17	63,05	95,90	63,47	95,62	63,87	115
61,47	98,10	61,90	97,83	62,32	97,56	62,75	97,29	63,18	97,01	63,60	96,73	64,02	96,45	64,45	116
62,00	98,95	62,43	98,67	62,86	98,40	63,29	98,13	63,72	97,84	64,15	97,57	64,58	97,28	64,99	117
62,63	99,79	62,97	99,52	63,40	99,24	63,83	98,97	64,27	98,68	64,70	98,40	65,13	98,13	65,54	118
63,06	100,6	63,50	100,4	63,94	100,1	64,38	99,71	64,81	99,52	65,24	99,23	65,68	98,98	66,20	119
63,59	101,5	64,03	101,2	64,48	100,9	64,91	100,6	65,36	100,4	65,79	100,1	66,23	99,78	66,67	120
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
lin.	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
Deg.	57 Degrees							56 Degrees							

Distance	34 Degrees								35 Degrees							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 M
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
1	0,83	0,56	0,83	0,56	0,82	0,57	0,82	0,57	0,82	0,57	0,82	0,58	0,81	0,58	0,81
2	1,66	1,12	1,65	1,13	1,65	1,13	1,64	1,14	1,64	1,15	1,63	1,15	1,63	1,16	1,62
3	2,49	1,69	2,47	1,69	2,47	1,70	2,46	1,71	2,46	1,72	2,45	1,73	2,44	1,74	2,43
4	3,32	2,25	3,30	2,25	3,30	2,27	3,29	2,28	3,28	2,29	3,27	2,30	3,26	2,32	3,25
5	4,15	2,81	4,13	2,81	4,12	2,83	4,11	2,85	4,10	2,87	4,08	2,89	4,07	2,90	4,06
6	4,97	3,36	4,96	3,38	4,94	3,40	4,93	3,42	4,91	3,44	4,90	3,46	4,88	3,48	4,87
7	5,80	3,91	5,79	3,94	5,77	3,96	5,75	3,99	5,73	4,01	5,72	4,04	5,69	4,06	5,68
8	6,63	4,47	6,61	4,50	6,59	4,53	6,57	4,56	6,55	4,59	6,53	4,62	6,51	4,65	6,49
9	7,46	5,03	7,44	5,06	7,42	5,10	7,39	5,13	7,37	5,16	7,35	5,19	7,33	5,23	7,30
10	8,29	5,59	8,27	5,63	8,24	5,66	8,22	5,70	8,19	5,74	8,17	5,77	8,14	5,81	8,12
11	9,12	6,15	9,09	6,19	9,06	6,23	9,04	6,27	9,01	6,31	8,98	6,34	8,95	6,39	8,93
12	9,95	6,71	9,92	6,75	9,89	6,80	9,86	6,84	9,83	6,88	9,80	6,93	9,77	6,97	9,74
13	10,78	7,27	10,75	7,32	10,71	7,36	10,68	7,41	10,65	7,46	10,62	7,50	10,58	7,55	10,55
14	11,61	7,83	11,57	7,88	11,54	7,93	11,50	7,98	11,47	8,03	11,43	8,08	11,40	8,13	11,36
15	12,44	8,39	12,40	8,44	12,36	8,49	12,33	8,55	12,29	8,60	12,25	8,66	12,21	8,71	12,17
16	13,26	8,95	13,23	9,01	13,19	9,06	13,15	9,12	13,11	9,18	13,07	9,23	13,02	9,21	12,99
17	14,09	9,51	14,05	9,57	14,01	9,63	13,98	9,69	13,92	9,75	13,88	9,81	13,84	9,87	13,80
18	14,92	10,06	14,88	10,13	14,83	10,19	14,79	10,26	14,74	10,33	14,70	10,39	14,65	10,45	14,61
19	15,75	10,62	15,71	10,69	15,66	10,76	15,61	10,83	15,56	10,90	15,52	10,94	15,47	11,03	15,42
20	16,58	11,18	16,53	11,26	16,48	11,33	16,43	11,40	16,38	11,47	16,33	11,54	16,28	11,61	16,23
21	17,41	11,74	17,36	11,82	17,31	11,89	17,25	11,97	17,20	12,05	17,15	12,12	17,10	12,19	17,04
22	18,24	12,30	18,19	12,38	18,13	12,46	18,08	12,54	18,02	12,62	17,98	12,70	17,91	12,78	17,85
23	19,07	12,86	19,01	12,95	18,95	13,03	18,90	13,11	18,84	13,19	18,78	13,27	18,52	13,36	18,67
24	19,90	13,42	19,84	13,51	19,78	13,59	19,72	13,68	19,66	13,77	19,60	13,85	19,34	13,94	19,48
25	20,73	13,98	20,67	14,08	20,60	14,16	20,54	14,25	20,48	14,34	20,41	14,43	20,15	14,52	20,29
26	21,56	14,54	21,49	14,64	21,43	14,72	21,36	14,82	21,30	14,92	21,23	15,00	20,97	15,10	21,10
27	22,38	15,10	22,32	15,20	22,25	15,29	22,19	15,39	22,12	15,49	22,05	15,58	21,78	15,68	21,91
28	23,21	15,66	23,15	15,77	23,07	15,86	23,01	15,96	22,93	16,06	22,87	16,17	22,59	16,26	22,73
29	24,04	16,22	23,97	16,33	23,90	16,42	23,83	16,53	23,75	16,64	23,69	16,75	23,41	16,84	23,54
30	24,87	16,78	24,80	16,88	24,72	16,99	24,65	17,10	24,57	17,21	24,50	17,31	24,42	17,42	24,35
31	25,70	17,33	25,62	17,45	25,55	17,56	25,47	17,67	25,39	17,78	25,32	17,89	25,24	18,00	25,16
32	26,53	17,89	26,45	18,01	26,37	18,12	26,29	18,24	26,21	18,35	26,13	18,47	26,05	18,58	25,97
33	27,36	18,45	27,28	18,57	27,20	18,69	27,12	18,81	27,03	18,93	26,95	19,05	26,87	19,16	26,78
34	28,19	19,01	28,11	19,14	28,02	19,26	27,94	19,38	27,85	19,50	27,77	19,62	27,68	19,74	27,59
35	29,02	19,57	28,93	19,70	28,84	19,82	28,76	19,95	28,67	20,08	28,58	20,20	28,49	20,33	28,41
36	29,84	20,13	29,76	20,26	29,67	20,39	29,58	20,52	29,49	20,65	29,40	20,78	29,31	20,91	29,22
37	30,67	20,69	30,59	20,82	30,49	20,95	30,40	21,09	30,31	21,22	30,22	21,35	30,12	21,49	30,03
38	31,50	21,25	31,41	21,39	31,32	21,52	31,23	21,66	31,13	21,80	31,03	21,93	30,94	22,07	30,84
39	32,33	21,81	32,24	21,95	32,14	22,09	32,05	22,23	31,95	22,51	31,85	22,51	31,75	22,65	31,65
40	33,16	22,37	33,06	22,51	32,96	22,66	32,87	22,80	32,77	22,94	32,67	23,09	32,56	23,23	32,46
41	33,99	22,93	33,89	23,07	33,79	23,22	33,69	23,37	33,58	23,52	33,48	23,66	33,38	23,81	33,27
42	34,82	23,49	34,72	23,64	34,61	23,79	34,51	23,94	34,40	24,09	34,30	24,24	34,19	24,39	34,09
43	35,65	24,04	35,54	24,20	35,44	24,35	35,33	24,51	35,22	24,66	35,12	24,82	35,01	24,97	34,90
44	36,48	24,60	36,37	24,76	36,26	24,92	36,15	25,08	36,04	25,24	35,93	25,35	35,82	25,55	35,71
45	37,31	25,16	37,20	25,33	37,08	25,49	36,98	25,65	36,86	25,81	36,75	25,97	36,63	26,13	36,52
46	38,14	25,72	38,03	25,89	37,91	26,05	37,80	26,22	37,68	26,39	37,57	26,55	37,45	26,71	37,33
47	38,96	26,28	38,85	26,45	38,73	26,62	38,62	26,79	38,50	26,96	38,38	27,12	38,26	27,29	38,15
48	39,79	26,84	39,68	27,02	39,56	27,18	39,44	27,36	39,32	27,53	39,20	27,70	39,07	27,88	38,96
49	40,62	27,40	40,51	27,58	40,39	27,75	40,26	27,93	40,14	28,11	40,02	28,28	39,89	28,46	39,77
50	41,45	27,96	41,33	28,14	41,21	28,32	41,08	28,50	40,96	28,68	40,83	28,86	40,71	29,03	40,58
51	42,28	28,52	42,16	28,70	42,03	28,89	41,90	29,07	41,78	29,25	41,65	29,93	41,52	29,62	41,39
52	43,11	29,08	42,98	29,27	42,85	29,45	42,73	29,64	42,60	29,83	42,47	30,0	42,33	30,20	42,20
53	43,94	29,64	43,81	29,83	43,68	30,02	43,55	30,21	43,41	30,40	43,28	30,59	43,15	30,78	43,01
54	44,77	30,20	44,64	30,39	44,50	30,58	44,37	30,78	44,23	30,97	44,10	31,17	43,96	31,36	43,83
55	45,60	30,75	45,46	30,95	45,33	31,15	45,19	31,35	45,05	31,55	44,92	31,74	44,78	31,94	44,64
56	46,43	31,31	46,29	31,52	46,15	31,72	46,01	31,92	45,87	32,12	45,73	32,32	45,59	32,52	45,45
57	47,25	31,87	47,12	32,08	46,97	32,28	46,84	32,49	46,69	32,70	46,55	32,90	46,40	33,10	46,26
58	48,08	32,43	47,95	32,64	47,80	32,85	47,66	33,06	47,51	33,27	47,37	33,47	47,22	33,68	47,07
59	48,91	32,99	48,77	33,30	48,62	33,41	48,48	33,63	48,33	33,84	48,18	34,95	48,03	34,26	47,89
60	49,74	33,55	49,59	33,77	49,45	33,98	49,30	34,20	49,15	34,41	49,00	34,63	48,85	34,84	48,69
Distance	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 M
	56 Deg.		55 Degrees								54 Degrees				

34 Degrees							35 Degrees								Distance
Min.	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
34,11	50,42	34,33	50,27	34,55	50,12	34,77	49,97	34,99	49,81	35,21	49,66	35,42	49,51	35,64	61
34,67	51,25	34,89	51,10	35,12	50,94	35,34	56,79	35,56	50,63	35,78	50,47	36,00	50,32	36,22	62
35,23	52,08	35,46	51,92	35,68	51,76	35,91	51,61	36,14	51,45	36,37	51,29	36,58	51,13	36,81	63
35,79	52,90	36,02	52,74	36,25	52,59	36,48	52,42	36,71	52,27	36,94	52,10	37,17	51,94	37,39	64
36,35	53,73	36,58	53,51	36,81	53,41	37,05	53,24	37,28	53,07	37,51	52,92	37,75	52,75	37,98	65
36,90	54,56	37,15	54,39	37,38	54,23	37,62	54,06	37,86	53,90	38,09	53,75	38,33	53,56	38,56	66
37,46	55,38	37,71	55,22	37,95	55,05	38,19	54,88	38,43	54,72	38,67	54,54	38,91	54,38	39,14	67
38,02	56,21	38,27	56,04	38,51	55,87	38,76	55,70	39,01	55,53	39,24	55,36	39,49	55,19	39,73	68
38,58	57,04	38,83	56,86	39,08	56,70	39,33	56,52	39,58	56,35	39,82	56,17	40,07	56,00	40,31	69
39,14	57,86	39,40	57,69	39,65	57,52	39,90	57,34	40,15	57,16	40,40	56,99	40,65	56,81	40,89	70
39,70	58,69	39,96	58,51	40,21	58,34	40,47	58,16	40,72	57,98	40,98	57,80	41,23	57,62	41,48	71
40,26	59,51	40,52	59,34	40,78	59,16	41,04	58,98	41,30	58,80	41,55	58,62	41,81	58,43	42,07	72
40,82	60,34	41,08	60,16	41,35	59,98	41,61	59,80	41,87	59,61	42,13	59,43	42,39	59,25	42,65	73
41,38	61,17	41,65	60,98	41,91	60,80	42,18	60,62	42,45	60,43	42,71	60,24	42,97	60,05	43,23	74
41,94	62,00	42,21	61,81	42,48	61,63	42,75	61,44	43,02	61,25	43,29	61,06	43,55	60,87	43,82	75
42,50	62,80	42,77	62,63	43,04	62,45	43,32	62,25	43,59	62,07	43,86	61,87	44,13	61,68	44,40	76
43,06	63,65	43,34	63,46	43,61	63,27	43,89	63,07	44,17	62,88	44,44	62,69	44,72	62,49	44,99	77
43,61	64,48	43,90	64,28	44,18	64,09	44,46	63,89	44,74	63,70	45,02	63,50	45,30	63,31	45,57	78
44,17	65,30	44,46	65,10	44,74	64,91	45,03	64,71	45,32	64,52	45,59	64,31	45,88	64,12	46,15	79
44,73	66,13	45,02	65,93	45,31	65,73	45,60	65,53	45,89	65,33	46,17	65,13	46,46	64,93	46,74	80
45,29	66,95	45,59	66,75	45,88	66,54	46,17	66,35	46,46	66,15	46,74	65,94	47,04	65,74	47,32	81
45,85	67,78	46,15	67,58	46,44	67,38	46,74	67,17	47,03	66,96	47,32	66,76	47,62	66,55	47,91	82
46,41	68,61	46,71	68,40	47,01	68,20	47,31	67,99	47,61	67,78	47,90	67,57	48,20	67,36	48,49	83
46,97	69,43	47,28	69,23	47,58	69,09	47,88	68,81	48,18	68,60	48,47	68,39	48,78	68,17	49,08	84
47,53	70,26	47,84	70,05	48,14	69,84	48,45	69,63	48,76	69,42	49,05	69,20	49,36	68,99	49,66	85
48,09	71,09	48,40	70,87	48,71	70,66	49,02	70,45	49,33	70,23	49,63	70,01	49,94	69,80	50,24	86
48,65	71,92	48,96	71,70	49,27	71,49	49,59	71,26	49,90	71,05	50,20	70,83	50,52	70,61	50,83	87
49,21	72,74	49,53	72,52	49,84	72,31	50,16	72,08	50,48	71,87	50,78	71,64	51,10	71,42	51,41	88
49,77	73,57	50,09	73,35	50,41	73,13	50,73	72,90	51,05	72,68	51,36	72,46	51,68	72,23	52,00	89
50,33	74,39	50,65	74,17	50,98	73,95	51,30	73,72	51,62	73,50	51,94	73,27	52,26	73,04	52,58	90
50,89	75,22	51,21	75,00	51,54	74,77	51,87	74,54	52,20	74,31	52,52	74,08	52,84	73,85	53,17	91
51,44	76,05	51,78	75,82	52,11	75,59	52,44	75,36	52,77	75,13	53,10	74,90	53,42	74,67	53,75	92
51,00	76,87	52,34	76,64	52,67	76,41	53,01	76,18	53,34	75,95	53,67	75,71	54,01	75,48	54,34	93
51,56	77,70	52,90	77,47	53,24	77,24	53,58	77,00	53,94	76,77	54,25	76,53	54,59	76,29	54,92	94
52,12	78,53	53,47	78,29	53,81	78,06	54,15	77,82	54,49	77,58	54,83	77,34	55,17	77,10	55,50	95
52,68	79,35	54,03	79,12	54,37	78,88	54,72	78,64	55,07	78,40	55,41	78,15	55,75	77,91	56,09	96
53,24	80,18	54,59	79,94	54,94	79,70	55,29	79,46	55,64	79,22	55,98	78,97	56,33	78,72	56,67	97
54,80	81,01	55,15	80,76	55,56	80,50	55,86	80,28	56,21	80,03	56,56	79,78	56,91	79,53	57,26	98
55,36	81,84	55,72	81,59	56,07	81,35	56,43	81,10	56,79	80,85	57,14	80,60	57,49	80,35	57,84	99
55,92	82,66	56,28	82,41	56,64	82,16	57,00	81,91	57,36	81,66	57,71	81,41	58,07	81,16	58,43	100
56,48	83,49	56,84	83,24	57,21	82,99	57,57	82,73	57,93	82,48	58,29	82,23	58,65	81,97	59,01	101
57,03	84,31	57,41	84,06	57,77	83,81	58,14	83,55	58,49	83,30	58,87	83,04	59,23	82,78	59,59	102
57,59	85,14	57,97	84,88	58,34	84,63	58,71	84,37	59,06	84,11	59,45	83,85	59,81	83,59	60,18	103
58,14	85,97	58,53	85,71	58,91	85,45	59,28	85,19	59,63	84,93	60,02	84,67	60,39	84,41	60,76	104
58,70	86,79	59,09	86,53	59,47	86,27	59,85	86,01	60,21	85,75	60,60	85,48	60,97	85,29	61,35	105
59,26	87,62	59,66	87,36	60,04	87,10	60,42	86,83	60,78	86,57	61,18	86,30	61,56	86,08	61,93	106
59,82	88,45	60,22	88,18	60,60	87,92	60,99	87,65	61,36	87,38	61,75	87,11	62,14	86,90	62,51	107
60,38	89,27	60,78	89,00	61,17	88,74	61,56	88,47	61,93	88,20	62,33	87,92	62,72	87,71	63,10	108
60,94	90,10	61,35	89,83	61,74	89,56	62,13	89,29	62,52	89,02	62,91	88,74	63,30	88,53	63,68	109
61,51	90,92	61,91	90,65	62,30	90,38	62,70	90,11	63,09	89,83	63,49	89,55	63,88	89,27	64,27	110
62,07	91,75	62,47	91,48	62,87	91,20	63,27	90,93	63,67	90,65	64,06	90,37	64,46	90,08	64,85	111
62,63	92,58	63,03	92,30	63,44	92,03	63,84	91,74	64,24	91,46	64,64	91,18	65,04	90,90	65,44	112
63,19	93,41	63,60	93,13	64,00	92,85	64,45	92,56	64,82	92,28	65,22	91,99	65,62	91,71	66,02	113
63,75	94,23	64,16	93,95	64,57	93,67	64,98	93,38	65,39	93,10	65,79	92,81	66,20	92,52	66,60	114
64,31	95,06	64,72	94,77	65,15	94,49	65,55	94,20	65,06	93,91	66,37	93,62	66,78	93,33	67,19	115
64,86	95,89	65,29	95,60	65,71	95,31	66,12	95,02	66,54	94,73	66,95	94,44	67,36	94,15	67,77	116
65,42	96,71	65,85	96,42	66,28	96,14	66,69	95,84	67,11	95,55	67,53	95,25	67,94	94,96	68,36	117
65,98	97,54	66,41	97,25	66,84	96,96	67,26	96,66	67,69	96,37	68,10	96,06	68,52	95,77	68,94	118
66,54	98,37	66,97	98,07	67,41	97,78	67,83	97,48	68,26	97,18	68,68	96,88	69,11	96,58	69,52	119
67,10	99,19	67,54	98,90	67,97	98,60	68,40	98,30	68,83	98,00	69,26	97,69	69,68	97,39	70,11	120
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Distance
0 Min.	45 Min.		30 Min.		15 Min		0 Min		45 Min.		30 Min		15 Min.		
56 Deg.	55 Degrees								54 Degrees						

Distance	36 Degrees								37 Degrees						
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 M
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep	Lat.
1	0,81	0,59	0,81	0,59	0,80	0,59	0,81	0,60	0,80	0,60	0,80	0,60	0,79	0,61	0,79
2	1,62	1,18	1,61	1,18	1,61	1,19	1,60	1,20	1,60	1,20	1,59	1,21	1,59	1,22	1,58
3	2,43	1,76	2,42	1,77	2,41	1,78	2,40	1,79	2,40	1,80	2,39	1,82	2,38	1,83	2,37
4	3,24	2,35	3,23	2,36	3,21	2,38	3,20	2,39	3,20	2,41	3,18	2,42	3,17	2,43	3,16
5	4,04	2,94	4,03	2,96	4,02	2,97	4,01	2,99	3,99	3,01	3,98	3,03	3,97	3,04	3,95
6	4,85	3,53	4,84	3,55	4,82	3,57	4,81	3,59	4,79	3,61	4,78	3,63	4,76	3,65	4,74
7	5,66	4,11	5,64	4,14	5,63	4,16	5,61	4,19	5,59	4,21	5,57	4,24	5,55	4,26	5,53
8	6,47	4,70	6,45	4,73	6,43	4,76	6,41	4,79	6,39	4,81	6,37	4,84	6,35	4,87	6,33
9	7,28	5,29	7,26	5,32	7,23	5,35	7,21	5,38	7,19	5,42	7,16	5,45	7,14	5,48	7,12
10	8,09	5,88	8,06	5,91	8,04	5,95	8,01	5,98	7,99	6,02	7,96	6,05	7,93	6,09	7,91
11	8,90	6,46	8,87	6,50	8,84	6,54	8,81	6,58	8,78	6,62	8,76	6,66	8,73	6,70	8,70
12	9,71	7,05	9,68	7,10	9,65	7,14	9,61	7,18	9,58	7,22	9,55	7,26	9,52	7,30	9,49
13	10,52	7,64	10,48	7,69	10,45	7,73	10,43	7,78	10,38	7,82	10,35	7,87	10,31	8,91	10,28
14	11,33	8,23	11,29	8,28	11,25	8,33	11,21	8,37	11,18	8,43	11,14	8,47	11,11	8,52	11,07
15	12,13	8,82	12,09	8,87	12,06	8,93	12,01	8,96	11,98	9,03	11,94	9,08	11,90	9,13	11,86
16	12,94	9,40	12,90	9,46	12,86	9,52	12,82	9,56	12,77	9,63	12,74	9,68	12,69	9,74	12,65
17	13,75	9,99	13,71	10,0	13,67	10,11	13,62	10,16	13,57	10,23	13,53	10,29	13,48	10,35	13,44
18	14,56	10,58	14,51	10,64	14,47	10,71	14,42	10,76	14,37	10,83	14,33	10,89	14,28	11,96	14,23
19	15,37	11,17	15,32	11,23	15,27	11,30	15,22	11,36	15,17	11,44	15,12	11,50	15,07	11,57	15,02
20	16,18	11,76	16,13	11,83	16,08	11,90	16,02	11,97	15,97	12,04	15,92	12,11	15,87	12,17	15,81
21	16,99	12,34	16,93	12,42	16,88	12,49	16,83	12,56	16,77	12,64	16,72	12,71	16,66	12,78	16,60
22	17,80	12,93	17,74	13,01	17,68	13,09	17,63	13,16	17,57	13,24	17,51	13,32	17,45	13,39	17,40
23	18,61	13,52	18,55	13,60	18,49	13,68	18,43	13,76	18,37	13,84	18,31	13,92	18,25	14,00	18,19
24	19,42	14,11	19,35	14,19	19,29	14,28	19,23	14,35	19,17	14,44	19,10	14,58	19,04	14,61	18,98
25	20,22	14,70	20,16	14,78	20,20	14,87	20,03	14,96	20,97	15,05	19,90	15,13	19,83	15,22	19,77
26	21,03	15,28	20,96	15,37	20,99	15,47	20,83	15,55	20,77	15,65	20,70	15,74	20,62	15,83	20,56
27	21,84	15,87	21,77	15,96	21,79	16,06	21,63	16,15	21,57	16,25	21,49	16,34	21,42	16,44	21,35
28	22,65	16,46	22,58	16,55	22,60	16,66	22,43	16,75	22,26	16,85	22,29	16,95	22,21	17,05	22,14
29	23,46	17,05	23,38	17,14	23,31	17,25	23,33	17,35	23,16	17,45	23,08	17,55	23,00	17,66	22,93
30	24,27	17,63	24,19	17,74	24,12	17,84	24,04	17,95	23,96	18,05	23,88	18,16	23,79	18,26	23,72
31	25,08	18,22	25,00	18,33	24,92	18,44	24,84	18,55	24,76	18,66	24,68	18,76	24,59	18,87	24,51
32	25,89	18,81	25,80	18,92	25,72	19,03	25,64	19,15	25,56	19,26	25,47	19,37	25,39	19,48	25,30
33	26,70	18,40	26,61	19,51	26,53	19,63	26,44	19,74	26,36	19,86	26,27	19,97	26,18	20,09	26,09
34	27,51	19,99	27,42	20,10	27,33	20,22	27,24	20,34	27,15	20,46	27,06	20,58	26,97	20,70	26,88
35	28,32	20,57	28,22	20,69	28,14	20,82	28,04	20,94	27,95	21,06	27,86	21,18	27,77	21,31	27,68
36	29,12	21,16	29,03	21,28	28,94	21,41	28,84	21,54	28,75	21,67	28,66	21,79	28,56	21,92	28,47
37	29,93	21,75	29,83	21,88	29,74	22,01	29,64	22,14	29,55	22,27	29,45	22,39	29,35	22,53	29,26
38	30,74	22,34	30,64	22,47	30,55	22,60	30,45	22,73	30,35	22,87	30,25	23,00	30,14	23,14	30,05
39	31,55	22,93	31,45	23,06	31,35	23,20	31,25	23,33	31,15	23,47	31,05	23,60	30,94	23,75	30,84
40	32,36	23,51	32,26	23,65	32,15	23,79	32,05	23,93	31,95	24,27	31,84	24,21	31,73	24,35	31,63
41	33,17	24,30	33,06	24,24	32,96	24,39	32,85	24,53	32,74	24,67	32,64	24,82	32,53	24,96	32,42
42	33,98	24,8	33,87	24,83	33,76	24,98	33,65	25,13	33,54	25,28	33,43	25,42	33,32	25,57	33,21
43	34,79	25,48	34,68	25,42	34,57	25,58	34,45	25,73	34,34	25,88	34,23	26,03	34,11	26,18	34,00
44	35,60	26,06	35,48	26,02	35,37	26,17	35,25	26,32	35,14	26,48	35,02	26,63	34,91	26,79	34,79
45	36,41	26,65	36,29	26,61	36,17	26,97	36,05	26,92	35,94	27,08	35,82	27,24	35,70	27,39	35,58
46	37,21	27,24	37,09	27,20	36,98	27,36	36,86	27,52	36,74	27,68	36,62	27,84	36,49	28,00	36,37
47	38,02	27,83	37,90	27,79	37,78	27,96	37,66	28,12	37,54	28,29	37,41	28,45	37,28	28,61	37,16
48	38,83	28,42	38,71	28,38	38,59	28,55	38,46	28,72	38,34	28,89	38,21	29,05	38,08	29,22	37,96
49	39,64	29,00	39,51	28,97	39,39	29,15	39,26	29,31	39,14	29,49	39,00	29,66	38,87	29,83	38,75
50	40,45	29,59	40,32	29,57	40,19	29,74	40,06	29,91	39,93	30,09	39,80	30,26	39,67	30,44	39,53
51	41,26	30,18	41,13	30,16	41,00	30,34	40,86	30,51	40,73	30,69	40,60	30,87	40,46	31,05	40,33
52	42,07	30,77	41,93	30,75	41,80	30,93	41,66	31,11	41,52	31,29	41,39	31,47	41,25	31,66	41,12
53	4 ,87	31,35	42,74	31,34	42,60	31,53	42,47	31,71	42,32	31,90	42,19	32,08	42,05	32,26	41,91
54	43,68	31,94	43,55	31,93	43,41	32,12	43,27	32,31	43,12	32,50	42,98	32,68	42,84	32,87	42,70
55	44,49	32,53	44,35	32,52	44,21	32,72	44,07	32,91	43,92	33,10	43,78	33,29	43,63	33,48	43,49
56	45,30	33,11	45,16	33,11	45,02	33,31	44,87	33,51	44,72	33,70	44,58	33,89	44,43	34,09	44,28
57	46,11	33,69	45,96	33,70	45,82	33,91	45,67	34,11	45,51	34,30	45,37	34,50	45,22	34,70	45,07
58	46,92	34,28	46,77	34,29	46,62	34,50	46,47	34,70	46,31	34,91	46,17	35,10	46,01	35,31	45,86
59	47,73	34,87	47,58	34,88	47,43	35,10	47,27	35,30	47,11	35,51	46,96	35,71	46,80	35,82	46,65
60	48,54	35,46	48,39	35,48	48,23	35,69	48,07	35,90	47,92	36,11	47,76	36,32	47,60	36,53	47,44
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Mi
	54 Deg.		53 Degrees								52 Degrees				

36 Degrees								37 Degrees								Distance
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
t.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
35	35,85	49,19	36,07	49,04	36,28	48,88	36,50	48,72	36,71	48,56	36,92	48,39	37,13	48,23	37,34	61
16	36,44	49,99	36,66	49,84	36,88	49,68	37,09	49,52	37,31	49,35	37,53	49,19	37,74	49,02	37,96	62
97	37,03	50,80	37,25	50,64	37,47	50,48	37,69	50,31	37,91	50,15	38,13	49,98	38,35	49,81	38,57	63
78	37,62	51,61	37,84	51,45	38,07	51,28	38,29	51,11	38,52	50,94	38,74	50,77	38,96	50,60	39,18	64
59	38,21	52,42	38,43	52,25	38,66	52,08	38,89	51,91	39,12	51,74	39,34	51,57	39,57	51,40	39,79	65
39	38,79	53,22	39,02	53,06	39,26	52,88	39,49	52,71	39,72	52,54	39,95	52,36	40,18	52,19	40,40	66
20	39,38	54,03	39,62	53,86	39,85	53,68	40,08	53,51	40,32	53,33	40,55	53,15	40,79	52,98	41,02	67
01	39,97	54,83	40,21	54,66	40,45	54,48	40,68	54,31	40,92	54,13	41,16	53,94	41,40	53,77	41,63	68
82	40,56	55,65	40,80	55,47	41,04	55,28	41,28	55,11	41,53	54,92	41,76	54,74	42,00	54,56	42,24	69
63	41,14	56,45	41,39	56,27	41,64	56,09	41,88	55,90	42,13	55,72	42,37	55,53	42,61	55,35	42,85	70
44	41,73	57,26	41,98	57,07	42,22	56,89	42,48	56,70	42,73	56,52	42,97	56,3	43,22	56,14	43,47	71
25	42,32	58,06	42,57	57,88	42,83	57,69	43,08	57,50	43,33	57,31	43,58	57,14	43,83	56,93	44,08	72
06	42,91	58,87	43,16	58,68	43,42	58,49	43,68	58,30	43,94	58,11	44,18	57,93	44,44	57,72	44,69	73
87	43,50	59,67	43,76	59,49	44,02	59,29	44,27	59,10	44,53	58,90	44,79	58,73	45,05	58,51	45,30	74
68	44,08	60,48	44,35	60,29	44,61	60,09	44,87	59,90	45,14	59,70	45,39	59,52	45,66	59,30	45,91	75
8	44,67	61,29	44,93	61,09	45,21	60,89	45,48	60,70	45,74	60,49	46,00	60,31	46,27	60,09	46,53	76
9	45,26	62,09	45,53	61,90	45,80	61,69	46,07	61,51	46,34	61,29	46,60	61,11	46,88	60,88	47,14	77
0	45,85	62,90	46,12	62,70	46,40	62,50	46,67	62,31	46,94	62,09	47,21	61,90	47,48	61,68	47,75	78
1	46,44	63,70	46,71	63,57	46,99	63,30	47,26	63,10	47,54	62,88	47,81	62,69	48,09	62,47	48,36	79
8	47,02	64,51	47,30	64,31	47,59	64,10	47,87	63,89	48,15	63,68	48,42	63,47	48,70	63,25	48,98	80
3	47,61	65,32	47,90	65,11	48,18	64,90	48,46	64,69	48,75	64,48	49,03	64,20	49,31	64,0	49,59	81
4	48,20	66,13	48,49	65,92	48,78	65,70	49,06	65,49	49,35	65,27	49,63	65,05	49,92	64,84	50,20	82
5	48,79	66,93	49,08	66,72	49,37	66,50	49,66	66,29	49,95	66,07	50,24	65,85	50,53	65,63	50,81	83
6	49,37	67,74	49,67	67,52	49,97	67,30	50,26	67,09	50,55	66,86	50,84	66,64	51,14	66,42	51,43	84
7	49,96	68,54	50,26	68,33	50,56	68,10	50,86	67,89	51,16	67,66	51,45	67,43	51,75	67,21	52,04	85
7	50,55	69,35	50,85	69,13	51,16	68,91	51,45	68,68	51,76	68,46	52,05	68,23	52,36	68,00	52,65	86
8	51,14	70,16	51,44	69,94	51,75	69,71	52,05	69,48	52,36	69,25	52,66	69,02	52,96	68,79	53,26	87
9	51,73	70,96	52,03	70,74	52,35	70,51	52,66	70,28	52,96	70,05	53,26	69,81	53,57	69,58	53,87	88
0	52,31	71,77	52,62	71,54	52,95	71,31	53,26	71,08	53,56	70,84	53,87	70,60	54,18	70,37	54,49	89
1	52,90	72,58	53,22	72,35	53,53	72,11	53,85	71,88	54,16	71,64	54,48	71,40	54,79	71,16	55,10	90
1	53,49	73,39	53,81	73,15	54,13	72,91	54,45	72,68	54,77	72,44	55,08	72,19	55,40	71,95	55,71	91
2	54,08	74,19	54,40	73,95	54,72	73,71	55,04	73,48	55,37	73,23	55,69	72,99	56,01	72,74	56,32	92
3	54,66	74,99	54,99	74,76	55,32	74,52	55,64	74,27	55,97	74,03	56,29	73,78	56,61	73,53	56,94	93
4	55,25	75,80	55,58	75,56	55,91	75,32	56,24	75,07	56,57	74,82	56,90	74,57	57,22	74,33	57,55	94
	55,84	76,61	56,17	76,37	56,51	76,12	50,84	75,87	57,17	75,62	57,50	75,37	57,83	75,12	58,16	95
6	56,43	77,42	56,76	77,17	57,10	76,92	57,44	76,67	57,78	76,42	58,11	76,16	58,44	75,91	58,77	96
7	57,02	78,22	57,35	77,97	57,70	77,72	58,03	77,47	58,38	77,21	58,71	79,95	59,05	76,70	59,38	97
7	57,60	79,03	57,95	78,70	58,29	78,52	58,63	78,27	58,98	78,01	59,32	77,75	59,66	77,49	60,00	98
8	58,19	79,83	58,54	79,50	58,89	79,32	59,23	79,07	59,58	78,80	59,92	78,54	60,27	78,28	60,61	99
0	58,78	80,64	59,13	80,39	59,48	80,12	59,83	79,86	60,18	79,60	60,53	79,33	60,88	79,07	61,23	100
1	59,37	81,55	59,72	81,19	60,08	80,93	60,43	80,66	60,78	80,40	61,13	80,13	61,48	79,86	61,83	101
2	59,95	82,36	60,31	81,99	60,67	81,73	61,03	81,46	61,39	81,19	61,73	80,92	62,09	80,65	62,45	102
3	60,54	83,16	60,90	82,80	61,27	82,53	61,63	82,26	61,99	81,99	62,34	81,72	62,70	81,44	63,06	103
4	61,13	83,97	61,49	83,60	61,86	83,33	62,22	83,06	62,59	82,78	62,95	82,56	63,31	82,23	63,67	104
5	61,72	84,77	62,09	84,41	62,46	84,13	62,82	83,86	63,19	83,58	63,55	83,39	63,92	83,02	64,28	105
6	62,31	85,58	62,68	85,21	63,05	84,93	63,42	84,66	93,79	84,38	64,16	84,09	64,53	83,81	64,89	106
6	62,90	86,39	63,27	86,01	63,65	85,73	64,02	85,46	64,40	85,17	64,76	84,89	65,14	84,61	65,51	107
7	63,48	87,19	63,86	86,82	64,24	86,53	64,62	86,26	65,00	85,97	65,37	85,68	65,75	85,40	66,12	108
8	64,07	87,99	64,45	87,62	64,84	87,33	65,21	87,05	65,60	86,76	65,97	86,47	66,36	86,19	66,73	109
9	64,66	88,71	65,04	88,42	65,43	88,13	65,81	87,85	66,20	87,56	66,58	87,27	66,96	86,98	67,34	110
0	65,24	89,51	65,63	89,23	66,02	88,94	66,41	88,65	66,80	88,36	67,19	88,06	67,57	87,77	67,96	111
1	65,83	90,32	66,23	90,03	65,62	89,71	67,21	89,45	67,40	89,15	67,79	88,85	68,18	88,56	68,57	112
2	66,42	91,13	66,82	90,84	67,21	90,54	67,61	90,25	68,01	89,95	68,40	89,65	68,79	89,35	69,18	113
	67,01	91,93	67,41	91,64	67,81	91,34	68,21	91,05	68,61	90,74	69,00	90,44	69,40	90,14	69,79	114
4	67,60	92,74	68,00	92,45	68,40	92,14	68,80	91,84	69,21	91,54	69,61	91,23	70,01	90,93	70,40	115
5	68,18	93,54	68,59	93,25	69,00	92,94	69,40	92,64	69,81	92,34	70,27	92,03	70,62	91,72	71,02	116
5	68,77	94,35	69,18	94,05	69,59	93,74	70,00	93,44	70,41	93,13	70,82	92,82	71,23	92,51	71,63	117
6	69,36	95,16	69,77	94,86	70,19	94,55	70,60	94,24	71,02	93,93	71,42	93,61	71,84	93,3	72,24	118
7	69,95	95,96	70,3	95,66	70,78	95,35	71,20	95,04	71,62	94,72	72,03	94,41	72,44	94,09	72,8	119
8	70,53	96,77	70,96	96,46	71,38	96,15	71,80	95,84	72,22	95,52	72,63	95,20	73,05	94,86	73,47	120
D	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
5 Deg.		53 Degrees								52 Degrees						

Distance	38 Degrees								39 Degrees							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	De
1	0,78	0,62	0,79	0,62	0,78	0,63	0,78	0,63	0,78	0,63	0,77	0,63	0,77	0,64	0,77	0,
2	1,58	1,23	1,57	1,24	1,57	1,25	1,56	1,25	1,55	1,26	1,55	1,27	1,54	1,27	1,54	1,
3	2,36	1,85	2,36	1,86	2,35	1,87	2,34	1,88	2,33	1,89	2,32	1,90	2,32	1,91	2,31	1,
4	3,15	2,46	3,14	2,48	3,13	2,49	3,12	2,50	3,11	2,52	3,10	2,53	3,09	2,54	3,08	2,
5	3,94	3,08	3,93	3,10	3,91	3,11	3,90	3,13	3,89	3,15	3,87	3,16	3,86	3,18	3,84	3,
6	4,73	3,69	4,71	3,72	4,70	3,74	4,68	3,76	4,66	3,78	4,65	3,80	4,63	3,82	4,61	3,
7	5,52	4,31	5,50	4,33	5,48	4,36	5,46	4,38	5,44	4,41	5,42	4,43	5,40	4,45	5,38	4,
8	6,30	4,93	6,28	4,95	6,26	4,98	6,24	5,01	6,22	5,04	6,20	5,06	6,17	5,09	6,15	5,
9	7,09	5,54	7,07	5,57	7,04	5,60	7,02	5,63	6,99	5,66	6,97	5,69	6,95	5,73	6,92	5,
10	7,88	6,16	7,85	6,19	7,83	6,23	7,80	6,26	7,77	6,29	7,74	6,33	7,72	6,36	7,69	6,
11	8,67	6,77	8,64	6,81	8,61	6,85	8,58	6,89	8,55	6,92	8,52	6,97	8,49	6,99	8,46	7
12	9,46	7,39	9,42	7,43	9,39	7,47	9,36	7,51	9,33	7,55	9,29	7,59	9,26	7,63	9,23	7
13	10,24	8,00	10,21	8,05	10,17	8,09	10,14	8,14	10,10	8,18	10,07	8,23	10,03	8,27	10,00	8
14	11,03	8,62	10,99	8,67	10,96	8,72	10,92	8,76	10,88	8,81	10,84	8,80	10,89	8,91	10,76	8
15	11,82	9,24	11,78	9,29	11,74	9,34	11,70	9,39	11,65	9,44	11,62	9,49	11,58	9,54	11,53	9
16	12,61	9,85	12,56	9,91	12,52	9,96	12,48	10,02	12,43	10,07	12,39	10,13	12,35	10,18	12,30	10
17	13,40	10,47	13,35	10,52	13,31	10,59	13,26	10,64	13,21	10,70	13,16	10,76	13,12	10,81	13,07	10
18	14,18	11,08	14,13	11,14	14,09	11,21	14,04	11,27	13,99	11,33	13,94	11,39	13,89	11,45	13,84	11
19	14,97	11,70	14,92	11,76	14,87	11,83	14,82	11,89	14,77	11,96	14,71	12,02	14,66	12,09	14,61	12
20	15,76	12,31	15,71	12,38	15,05	12,45	15,60	12,52	15,54	12,59	15,49	12,65	15,43	12,72	15,38	12
21	16,55	12,93	16,49	13,00	16,44	13,07	16,38	13,14	16,32	13,22	16,26	13,29	16,20	13,36	16,15	13
22	17,34	13,55	17,27	13,62	17,22	13,70	17,16	13,77	17,10	13,85	17,04	13,92	16,98	13,99	16,92	14
23	18,12	14,16	18,06	14,24	18,00	14,32	17,94	14,40	17,87	14,47	17,81	14,55	17,75	14,63	17,68	14
24	18,91	14,78	18,85	14,86	18,78	14,94	18,72	15,02	18,65	15,10	18,58	15,18	18,52	15,26	18,45	15
25	19,70	15,39	19,63	15,46	19,57	15,57	19,50	15,65	19,43	15,73	19,36	15,82	19,29	15,90	19,22	15
26	20,49	16,01	20,41	16,08	20,35	16,19	20,28	16,27	20,21	16,36	20,13	16,45	20,07	16,53	19,99	16
27	21,28	16,63	21,20	16,70	21,13	16,81	21,06	16,90	20,98	16,99	20,91	17,08	21,84	17,17	20,76	17
28	22,06	17,24	21,99	17,31	21,92	17,43	21,84	17,53	21,76	17,62	21,69	17,72	22,61	17,81	21,53	17
29	22,85	17,86	22,77	17,93	22,70	18,06	22,62	18,15	22,54	18,25	22,46	18,35	23,38	18,44	22,29	18
30	23,64	18,47	23,56	18,57	23,48	18,66	23,39	18,78	23,32	18,88	23,23	18,98	23,15	19,08	23,07	19
31	24,43	19,89	24,35	19,19	24,26	19,30	24,18	19,41	24,09	19,51	24,01	19,61	23,93	19,72	23,83	19
32	25,22	19,70	25,13	19,81	25,04	19,92	24,96	20,03	24,87	20,14	24,78	20,25	24,69	20,35	24,60	20
33	26,00	20,32	25,92	20,43	25,83	20,54	25,74	20,66	25,65	20,77	25,55	20,88	25,47	20,99	25,37	21
34	26,79	20,93	26,70	21,05	26,61	21,17	26,52	21,28	26,43	21,40	26,33	21,51	26,24	21,63	26,14	21
35	27,58	21,55	27,49	21,67	27,39	21,79	27,30	21,91	27,20	22,03	27,10	22,15	27,01	22,26	26,91	22
36	28,37	22,17	28,27	22,29	28,18	22,41	28,07	22,53	27,98	22,65	27,88	22,78	27,78	22,90	27,68	23
37	29,16	22,78	29,06	22,91	28,96	23,04	28,86	23,16	28,75	23,28	28,65	23,41	28,55	23,53	28,45	23
38	29,94	23,4	29,84	23,53	29,74	23,66	29,64	23,79	29,53	23,91	29,42	24,05	29,33	24,17	29,22	24
39	30,73	24,01	30,63	24,14	30,53	24,28	30,42	24,41	30,31	24,54	30,20	24,68	30,09	24,81	29,99	24
40	31,52	24,63	31,41	24,76	31,30	24,90	31,20	25,04	31,09	25,17	30,98	25,31	30,87	25,44	30,75	25
41	32,31	25,24	32,20	25,38	32,09	25,52	31,98	25,66	31,87	25,80	31,75	25,94	31,64	26,08	31,52	26
42	33,10	25,86	32,98	26,00	32,87	26,15	32,76	26,29	32,64	26,43	32,52	26,57	32,41	26,72	32,29	26
43	33,88	26,47	33,77	26,62	33,65	26,77	33,54	26,92	33,42	27,06	33,30	27,21	33,18	27,35	33,06	27
44	34,67	27,09	34,55	27,24	34,44	27,39	34,32	27,54	34,2	27,70	34,07	27,84	33,95	27,99	33,83	28
45	35,46	27,71	35,34	27,86	35,22	28,02	35,10	28,17	34,97	28,32	34,85	28,49	34,73	28,62	34,60	28
46	36,25	28,32	36,12	28,48	36,00	28,64	35,88	29,79	35,75	28,95	35,62	29,11	35,50	29,26	35,37	29
47	37,04	28,94	36,91	29,10	36,78	29,26	36,66	29,42	36,53	29,58	36,39	29,74	36,27	29,90	36,14	30
48	37,82	29,55	37,69	29,72	37,57	29,88	37,44	30,05	37,30	30,27	37,17	30,37	37,04	30,53	36,91	30
49	38,61	30,17	38,48	30,34	38,35	30,50	38,22	30,67	38,08	30,83	37,94	31,01	37,81	31,17	37,68	31
50	39,40	30,78	39,27	30,96	39,13	31,13	38,99	31,30	38,86	31,47	38,72	31,64	38,58	31,80	38,44	31
51	40,19	31,40	40,05	31,57	39,91	31,75	39,77	31,92	39,64	32,10	39,49	32,27	39,35	32,44	39,21	32
52	40,98	32,02	40,84	32,19	40,70	32,37	40,5	32,55	40,41	32,72	40,27	32,90	40,13	33,08	39,98	33
53	41,77	32,63	41,62	32,81	41,48	33,00	41,33	33,17	41,19	33,35	41,04	33,54	40,90	33,71	40,75	33
54	42,55	33,25	42,41	33,43	42,26	33,62	42,11	33,80	41,97	33,98	41,82	34,17	41,67	34,34	41,52	34
55	43,34	33,86	43,19	34,05	43,04	34,24	42,89	34,43	42,75	34,61	42,59	34,80	42,44	34,98	42,29	35
56	44,13	34,48	43,98	34,67	43,83	34,86	43,67	35,05	43,52	35,24	43,36	35,43	43,21	35,62	43,06	35
57	44,92	35,10	44,76	25,29	44,61	35,49	44,45	35,68	44,30	35,87	44,15	36,07	43,99	36,26	43,83	36
58	45,71	35,71	45,55	35,91	45,39	36,11	45,23	36,30	45,07	36,50	44,93	36,70	44,76	36,89	44,59	37
59	46,49	36,33	46,33	36,53	46,18	36,73	46,01	36,93	45,85	37,13	45,70	37,33	45,53	37,53	46,36	37
60	47,28	36,94	47,12	37,15	46,96	37,35	46,79	37,56	46,63	37,76	46,40	37,96	46,30	38,17	46,13	38
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Mi	
	52 Deg.		51 Degrees								50 Degrees					

38 Degrees							39 Degrees								Diſtance
Min.	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
37,56	47,90	37,76	47,74	37,97	47,57	38,18	47,41	38,39	47,24	38,60	47,07	38,80	46,90	39,01	61
38,17	48,69	38,38	48,52	38,60	48,35	38,81	48,18	39,02	48,01	39,23	47,84	39,43	47,64	39,64	62
38,79	49,47	39,00	49,31	39,22	49,13	39,43	48,96	39,65	48,79	39,86	48,61	40,07	48,47	40,28	63
39,40	50,26	39,62	50,09	39,84	49,91	40,06	49,74	40,28	49,56	40,50	49,39	40,70	49,21	40,92	64
40,02	51,04	40,24	50,87	40,47	50,69	40,69	50,51	40,90	50,34	41,13	50,16	41,35	49,98	41,56	65
40,64	51,83	40,86	51,66	41,09	51,47	41,31	51,29	41,53	51,11	41,76	50,93	41,98	40,74	42,20	66
41,25	52,61	41,48	52,44	41,71	52,25	41,94	52,07	42,16	51,88	42,39	51,70	42,62	51,51	42,84	67
41,87	53,40	42,10	53,22	42,34	53,04	42,56	52,85	42,79	52,66	43,03	52,47	43,25	52,28	43,48	68
42,48	54,18	42,72	54,00	42,96	53,81	43,19	53,62	43,42	53,43	43,66	53,24	43,89	53,05	43,82	69
43,10	54,97	43,34	54,78	43,58	54,59	43,81	54,40	44,05	54,21	44,29	54,01	44,53	53,82	44,76	70
43,71	55,76	43,95	55,57	44,20	55,37	44,44	55,18	44,68	54,98	44,92	54,79	45,16	54,59	45,40	71
44,33	56,54	44,57	56,34	44,82	56,15	45,06	55,96	45,31	55,76	45,56	55,56	45,80	55,36	46,04	72
44,94	57,33	45,19	57,13	45,45	56,93	45,69	56,73	45,94	56,53	46,19	56,33	46,43	56,13	46,68	73
45,56	58,11	45,81	57,92	46,07	57,71	46,32	57,51	46,57	57,30	46,22	57,10	47,07	56,90	47,32	74
46,18	58,90	46,43	58,70	46,69	58,49	46,94	58,29	47,20	58,08	46,86	57,87	47,71	57,66	47,96	75
46,79	59,68	47,04	59,48	47,31	59,27	47,57	59,06	47,83	58,85	47,49	58,65	48,34	58,43	48,60	76
47,41	60,47	47,66	60,27	47,94	60,05	48,20	9,84	48,46	59,63	48,12	59,42	48,98	59,20	49,23	77
48,02	61,25	48,28	61,05	48,56	60,83	48,82	60,62	49,08	60,40	48,73	60,19	49,61	59,97	49,87	78
48,64	62,04	48,90	61,83	49,18	61,61	49,45	61,39	49,71	61,17	49,39	60,96	50,25	60,94	50,51	79
49,25	62,83	49,53	62,61	49,80	62,39	50,07	62,17	50,35	61,95	50,62	61,73	50,89	61,51	51,16	80
49,87	63,61	50,15	63,39	50,42	63,17	50,70	62,95	50,98	62,73	51,25	62,50	51,52	62,28	51,79	81
50,49	64,40	50,77	64,18	51,05	63,96	51,33	63,73	51,60	63,50	51,88	63,27	52,16	63,05	52,43	82
51,10	65,18	51,38	64,96	51,67	64,74	51,95	64,50	52,23	64,27	52,52	64,05	52,79	63,81	53,07	83
51,72	65,97	52,00	65,74	52,29	65,52	52,58	65,28	52,86	65,05	53,15	64,82	53,43	64,58	53,71	84
52,33	66,75	52,62	66,52	52,92	66,30	53,20	66,06	53,49	65,82	53,78	65,59	54,07	65,35	54,35	85
52,95	67,54	53,24	67,31	53,54	67,08	53,83	66,83	54,12	66,60	54,42	66,36	54,70	66,12	54,99	86
53,57	68,32	53,86	68,10	54,16	67,86	54,46	67,61	54,75	67,37	55,05	67,13	55,34	66,89	55,63	87
54,18	69,11	54,48	68,89	54,79	68,64	55,08	68,39	55,38	68,14	55,68	67,91	55,97	67,66	56,27	88
54,80	69,89	55,10	69,67	55,41	69,42	55,71	69,17	56,01	68,92	56,32	68,68	56,61	68,43	56,90	89
55,41	70,68	55,72	70,44	56,03	70,19	56,33	69,94	56,64	69,70	56,94	69,45	57,25	69,20	57,55	90
56,03	71,46	56,34	71,22	56,65	70,97	56,96	70,72	57,27	70,47	57,58	70,22	57,88	69,97	58,19	91
56,64	72,25	56,96	72,00	57,27	71,75	57,59	71,50	57,90	71,24	58,21	70,99	58,52	70,73	58,83	92
57,26	73,03	57,58	72,78	57,90	72,53	58,21	72,28	58,53	72,02	58,84	71,76	59,16	71,50	59,47	93
57,87	73,82	58,19	73,57	58,52	73,31	58,84	73,05	59,16	72,79	59,48	72,53	59,79	72,27	60,11	94
58,49	74,60	58,81	74,35	59,14	74,09	59,46	73,83	59,78	73,57	60,11	73,31	60,43	73,04	60,76	95
59,11	75,39	59,43	75,13	59,76	74,87	60,09	74,61	60,41	74,34	60,74	74,08	61,06	73,81	61,38	96
59,72	76,17	60,05	75,92	60,39	75,65	60,72	75,38	61,04	75,11	61,38	74,85	61,70	74,58	62,02	97
60,34	76,96	60,67	76,70	61,01	76,42	61,34	76,16	61,67	75,89	62,01	75,62	62,34	75,35	62,66	98
60,95	77,74	61,27	77,48	61,63	77,21	61,97	76,94	62,30	76,66	62,63	76,39	62,97	76,12	63,30	99
61,57	78,53	61,91	78,26	62,25	77,99	62,59	77,72	62,93	77,44	63,27	77,16	63,61	76,88	63,94	100
62,18	79,32	62,53	79,04	62,87	78,79	63,22	78,49	63,56	78,21	63,90	77,93	63,64	77,65	64,58	101
62,80	80,10	63,15	79,83	63,50	79,55	63,84	79,27	64,19	78,99	64,54	78,71	64,28	78,42	65,22	102
63,41	80,89	63,77	80,61	64,12	80,40	64,47	80,05	64,82	79,76	65,17	79,48	64,92	79,19	65,86	103
64,03	81,67	64,39	81,39	64,74	81,11	65,10	80,82	65,45	80,54	65,80	80,25	65,55	79,96	66,50	104
64,65	82,46	65,00	82,18	65,37	81,89	65,72	81,60	66,08	81,31	66,44	81,02	66,19	80,73	67,14	105
65,26	83,24	65,62	82,96	65,99	82,67	66,35	82,38	66,71	82,08	67,07	81,79	66,82	81,50	67,78	106
65,88	84,03	66,24	83,74	66,61	83,45	66,97	83,06	67,34	82,86	67,70	82,57	67,46	82,27	68,42	107
66,49	84,81	66,86	84,53	67,24	84,23	67,60	83,83	67,96	83,63	68,34	83,34	68,10	83,04	69,06	108
67,11	85,60	67,48	85,30	67,86	85,01	68,23	84,61	68,59	84,41	68,97	84,11	68,73	83,81	69,70	109
67,72	86,39	68,10	86,09	68,48	85,79	68,85	85,49	69,23	85,18	69,60	84,88	69,97	84,57	70,34	110
68,34	87,17	68,72	86,87	69,10	86,57	69,48	86,26	69,85	85,96	70,23	85,65	70,61	85,34	70,98	111
68,96	87,96	69,33	87,65	69,72	87,35	70,11	87,04	70,48	86,73	70,86	86,42	71,24	86,11	71,62	112
69,57	88,74	69,96	88,44	70,35	88,13	70,73	87,82	71,11	87,51	71,50	87,19	71,88	86,88	72,26	113
70,19	89,53	70,58	89,22	70,97	88,90	71,36	88,60	71,74	88,28	72,13	87,97	72,51	87,65	72,89	114
70,80	90,31	71,19	90,00	71,59	89,69	71,98	89,37	72,37	89,05	72,76	88,74	73,15	88,42	73,53	115
71,42	91,10	71,81	90,79	72,21	90,47	72,61	90,15	73,00	89,83	73,40	89,51	73,79	89,16	74,17	116
72,04	91,88	72,43	91,57	72,84	91,25	73,23	90,93	73,63	90,60	74,03	90,28	74,42	89,95	74,81	117
72,65	92,67	73,05	92,35	73,46	92,03	73,86	91,70	74,26	91,38	74,66	91,05	75,06	90,72	75,45	118
73,27	93,45	73,67	93,13	74,08	92,81	74,49	92,48	74,88	92,15	75,29	91,83	75,69	91,49	76,09	119
73,88	94,24	74,29	93,91	74,70	93,59	75,11	93,26	75,52	92,93	75,93	92,59	76,33	92,26	76,73	120
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Diſtance
Min.	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
Deg.	51 Degrees								50 Degrees						

Distance	40 Degrees								41 Degrees							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min		15 Min.		30 Min.		45 Min.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	De
1	0,77	0,64	0,76	0,65	0,76	0,65	0,76	0,65	0,76	0,66	0,75	0,66	0,75	0,66	0,75	0,
2	1,53	1,29	1,53	1,29	1,52	1,30	1,52	1,31	1,51	1,31	1,50	1,32	1,50	1,33	1,49	1,
3	2,30	1,93	2,29	1,94	2,28	1,95	2,27	1,96	2,26	1,97	2,26	1,98	2,25	1,99	2,24	2,
4	3,06	2,57	3,05	2,58	3,05	2,60	3,03	2,61	3,02	2,62	3,01	2,63	3,00	2,65	2,98	2,
5	3,83	3,21	3,82	3,23	3,80	3,25	3,78	3,26	3,77	3,28	3,76	3,30	3,75	3,31	3,73	3,
6	4,60	3,86	4,58	3,88	4,56	3,90	4,55	3,92	4,53	3,94	4,51	3,96	4,49	3,98	4,48	4,
7	5,36	4,5	5,34	4,52	5,32	4,55	5,30	4,57	5,28	4,59	5,26	4,62	5,24	4,64	5,22	4,
8	6,13	5,14	6,11	5,17	6,08	5,20	6,06	5,22	6,04	5,25	6,02	5,28	5,99	5,30	5,97	5,
9	6,89	5,79	6,87	5,82	6,84	5,85	6,82	5,88	6,79	5,91	6,77	5,93	6,74	5,96	6,72	5,
10	7,66	6,43	7,63	6,46	7,60	6,50	7,58	6,53	7,55	6,56	7,52	6,59	7,49	6,63	7,46	6,
11	8,43	7,07	8,40	7,11	8,37	7,14	8,33	7,18	8,30	7,22	8,27	7,25	8,24	7,29	8,21	7,
12	9,19	7,71	9,16	7,75	9,13	7,79	9,09	7,83	9,06	7,87	9,02	7,92	8,99	7,95	8,95	7,
13	9,96	8,36	9,92	8,40	9,89	8,44	9,85	8,49	9,81	8,53	9,77	8,57	9,74	8,61	9,70	8,
14	10,72	9,00	10,69	9,05	10,65	9,09	10,61	9,14	10,57	9,18	10,53	9,23	10,49	9,28	10,45	9,
15	11,49	9,64	11,45	9,69	11,41	9,74	11,37	9,79	11,32	9,84	11,28	9,89	11,24	9,94	11,19	9,
16	12,26	10,29	12,21	10,34	12,17	10,39	12,12	10,45	12,08	10,50	12,03	10,55	11,98	10,60	11,94	10,
17	13,02	10,93	12,98	10,98	12,93	11,04	12,88	11,09	12,83	11,15	12,78	11,21	12,73	11,27	12,68	11,
18	13,79	11,57	13,74	11,63	13,69	11,69	13,64	11,75	13,59	11,81	13,53	11,87	13,48	11,93	13,43	11,
19	14,55	12,21	14,50	12,28	14,4	12,34	14,40	12,40	14,34	12,46	14,29	12,53	14,23	12,59	14,18	12,
20	15,32	12,86	15,27	12,92	15,21	12,99	15,15	13,06	15,09	13,12	15,04	13,19	14,98	13,25	14,92	13,
21	16,09	13,50	16,03	13,57	15,97	13,64	15,91	13,71	15,85	13,78	15,79	13,85	15,73	13,92	15,67	13,
22	16,85	14,14	16,79	14,21	16,73	14,29	16,67	14,36	16,60	14,43	16,54	14,51	16,48	14,58	16,41	14,
23	17,62	14,79	17,55	14,86	17,49	14,91	17,43	15,01	17,36	15,09	17,30	15,16	17,23	15,24	17,16	15,
24	18,39	15,43	18,32	15,51	18,25	15,59	18,18	15,67	18,11	15,75	18,05	15,82	17,98	15,90	17,91	15,
25	19,15	16,07	19,08	16,15	19,01	16,23	18,94	16,32	18,87	16,39	18,80	16,48	18,73	16,57	18,65	16,
26	19,92	16,71	19,84	16,80	19,77	16,88	19,70	16,97	19,62	17,05	19,55	17,14	19,47	17,23	19,40	17,
27	20,68	17,36	20,61	17,44	20,53	17,53	20,46	17,63	20,38	17,70	20,30	17,80	20,22	17,89	20,14	17,
28	21,45	18,00	21,37	18,09	21,29	18,18	21,22	18,28	21,13	18,36	21,05	18,46	20,97	18,56	20,89	18,
29	22,22	18,64	22,13	18,74	22,05	18,83	21,97	18,93	21,89	19,02	21,81	19,12	21,72	19,22	21,64	19,
30	22,98	19,28	22,9	19,38	22,81	19,48	22,73	19,58	22,64	19,68	22,56	19,78	22,47	19,88	22,38	19,
31	23,75	19,93	23,66	20,03	23,57	20,13	23,49	20,24	23,39	20,34	23,31	20,44	23,22	20,54	23,13	20,
32	24,51	20,57	24,42	20,68	24,33	20,78	24,24	20,89	24,15	20,99	24,06	21,10	23,97	21,21	23,87	21,
33	25,28	21,21	25,19	21,32	25,09	21,43	25,00	21,54	24,91	21,65	24,81	21,76	24,72	21,86	24,62	21,
34	26,05	21,86	25,95	21,97	25,85	22,08	25,76	22,20	25,66	22,31	25,56	22,42	25,47	22,53	25,37	22,
35	26,81	22,50	26,71	22,61	26,61	22,73	26,52	22,85	26,42	22,96	26,32	23,08	26,21	23,19	26,11	23,
36	27,58	23,14	27,48	23,26	27,37	23,38	27,28	23,50	27,17	23,62	27,07	23,74	26,96	23,86	26,82	23,
37	28,34	23,79	28,24	23,91	28,13	24,03	28,03	24,15	27,93	24,37	27,82	24,39	27,71	24,52	27,60	24,
38	29,11	24,43	29,00	24,55	28,89	24,68	28,79	24,81	28,68	25,03	28,57	25,05	28,46	25,18	28,35	25,
39	29,88	25,07	29,76	25,20	29,65	25,33	29,55	25,46	29,44	25,69	29,32	25,71	29,21	25,85	29,10	25,
40	30,64	25,71	30,53	25,85	30,42	25,98	30,30	26,11	30,19	26,24	30,07	26,37	29,96	26,51	29,84	26,
41	31,41	26,36	31,29	26,49	31,18	26,63	31,06	26,76	30,94	26,90	30,83	27,03	30,71	27,17	30,59	27,
42	32,17	26,99	32,06	27,14	31,94	27,28	31,82	27,42	31,60	27,55	31,58	27,69	31,46	27,83	31,33	27,
43	32,94	27,64	32,82	27,78	32,70	27,93	32,58	28,07	32,35	28,21	32,33	28,35	32,20	28,49	32,08	28,
44	33,71	28,28	33,58	28,43	33,46	28,57	33,34	28,72	33,11	28,87	33,08	29,01	32,94	29,16	32,83	29,
45	34,47	28,93	34,34	29,08	34,22	29,22	34,09	29,38	33,86	29,52	33,83	29,67	33,69	29,82	33,57	29,
46	35,24	29,57	35,11	29,72	34,98	29,87	34,85	30,03	34,62	30,18	34,59	30,33	34,44	30,48	34,32	30,
47	36,00	30,21	35,87	30,37	35,74	30,52	35,61	30,68	35,37	30,83	35,34	30,99	35,19	31,15	35,06	31,
48	36,77	30,86	36,63	31,01	36,50	31,17	36,37	31,33	36,13	31,49	36,09	31,65	35,94	31,81	35,81	31,
49	37,54	31,50	37,40	31,66	37,26	31,82	37,13	31,99	36,88	32,15	36,84	32,31	36,69	32,47	36,56	32,
50	38,30	32,14	38,16	32,31	38,02	32,47	37,88	32,64	37,74	32,80	37,59	32,97	37,45	33,13	37,30	33,
51	39,07	32,78	38,93	32,95	38,78	33,12	38,64	33,29	38,49	33,46	38,24	33,63	38,20	33,79	38,05	33,
52	39,83	33,43	39,69	33,6	39,54	33,77	39,40	33,94	39,25	34,12	39,00	34,29	38,95	34,46	38,80	34,
53	40,60	34,07	40,45	34,24	40,30	34,42	40,15	34,60	40,00	34,77	39,75	34,95	39,70	35,12	39,54	35,
54	41,37	34,71	41,21	34,89	41,06	35,07	40,91	35,25	40,76	35,43	40,50	35,60	40,44	35,78	40,29	35,
55	42,13	35,66	41,98	35,54	41,82	35,72	41,67	35,90	41,51	36,08	41,25	36,26	41,19	36,45	41,03	36,
56	42,90	36,00	42,74	36,18	42,58	36,37	42,43	36,56	42,27	36,74	42,00	36,92	41,94	37,11	41,78	37,
57	43,66	36,64	43,50	36,83	43,34	37,02	43,19	37,21	42,92	37,40	42,76	37,58	42,69	37,77	42,53	37,
58	44,43	37,28	44,27	37,47	44,10	37,67	43,95	37,86	43,67	38,05	43,51	38,24	43,44	38,44	43,27	38,
59	45,20	37,93	45,03	38,12	44,86	38,31	44,70	38,52	44,43	38,71	44,26	38,90	44,19	39,10	44,02	39,
60	45,96	38,57	45,79	38,77	45,63	38,97	45,45	39,17	45,28	39,36	45,01	39,56	44,94	39,76	44,76	39,
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.	
	50 Deg.		49 Degrees								48 Degrees					

49 Degrees							41 Degrees								Distance
Min.	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
39,21	46,56	39,41	46,39	39,62	46,21	39,82	46,04	40,02	45,86	40,16	45,69	40,42	45,57	40,62	61
39,85	47,32	40,06	47,15	40,27	46,97	40,47	46,79	40,68	46,61	40,82	46,44	41,08	46,26	41,29	62
40,50	48,08	40,71	47,91	40,91	47,73	41,13	47,55	41,33	47,37	41,48	47,19	41,75	47,00	41,95	63
41,14	48,85	41,35	48,67	41,56	48,49	41,78	48,31	41,99	48,12	42,14	47,93	42,41	47,75	42,62	64
41,78	49,61	42,00	49,43	42,21	49,24	42,43	49,06	42,64	48,88	42,80	48,68	43,07	48,49	43,28	65
42,43	50,37	42,64	50,19	42,86	50,00	43,08	49,81	43,30	49,62	43,46	49,48	43,74	49,24	43,95	66
43,07	51,14	43,29	50,95	43,51	50,76	43,74	50,57	43,96	50,37	44,11	50,18	44,40	49,99	44,62	67
43,71	51,90	43,94	51,71	44,16	51,52	44,39	51,32	44,61	51,13	44,77	50,93	45,06	50,73	45,28	68
44,35	52,60	44,58	52,47	44,81	52,28	45,04	52,08	44,27	51,88	45,43	51,68	45,72	51,48	45,96	69
45,00	53,43	45,23	53,23	45,46	53,04	45,69	52,83	45,93	52,63	46,16	52,43	46,38	52,22	46,61	70
45,64	54,19	45,87	53,99	46,11	53,79	46,35	53,59	46,58	53,38	46,81	53,18	47,05	52,97	47,28	71
46,28	54,95	46,52	54,75	46,76	54,55	47,00	54,34	47,24	54,13	47,47	53,93	47,71	53,72	47,94	72
46,92	55,72	47,17	55,51	47,41	55,30	47,65	55,10	47,89	54,89	48,13	54,67	48,37	54,46	48,61	73
47,57	56,48	47,81	56,27	48,06	56,06	48,31	55,85	48,55	55,64	48,80	55,42	49,04	55,21	49,28	74
48,21	57,24	48,46	57,03	48,69	56,82	48,96	56,61	49,20	56,39	49,45	56,17	49,70	55,95	49,94	75
48,85	58,00	49,10	57,79	49,36	57,58	49,61	57,36	49,86	57,14	50,07	56,92	50,36	56,70	50,51	76
49,50	58,77	49,75	58,55	49,99	58,34	50,26	58,12	50,52	57,89	50,77	57,67	51,02	57,45	51,17	77
50,14	59,53	50,40	59,31	50,64	59,09	50,92	58,87	51,17	58,64	51,43	58,42	51,69	58,19	51,84	78
50,77	60,29	51,04	60,07	51,29	59,85	51,57	59,63	51,83	59,40	52,09	59,17	52,35	58,94	52,51	79
51,42	61,06	51,69	60,83	51,95	60,61	52,22	60,38	52,49	60,15	52,75	59,91	53,01	59,69	53,27	80
52,07	61,82	52,34	61,59	52,61	61,36	52,87	61,13	53,14	60,90	53,41	60,67	53,67	60,43	53,94	81
52,71	62,58	52,98	62,35	53,25	62,12	53,53	61,89	53,80	61,65	54,07	61,42	54,34	61,18	54,60	82
53,35	63,35	53,63	63,11	53,90	62,88	54,18	62,64	54,45	62,40	54,73	62,16	55,00	61,92	55,27	83
54,00	64,11	54,27	63,87	54,55	63,64	54,83	63,40	55,11	63,16	55,38	62,91	55,66	62,67	55,93	84
54,64	64,87	54,92	64,63	55,20	64,40	55,49	64,15	55,77	63,91	56,04	63,66	56,33	63,42	56,60	85
55,28	65,64	55,57	65,39	55,85	65,15	56,14	64,91	56,42	64,06	56,70	64,41	56,99	64,16	57,27	86
56,92	66,40	56,21	66,15	56,50	65,91	56,79	65,06	57,08	65,41	57,36	65,16	57,65	64,91	57,93	87
56,57	67,16	56,86	66,91	57,15	66,67	57,45	66,42	57,73	66,16	58,02	65,91	58,31	65,65	58,60	88
57,21	67,93	57,50	67,67	57,80	67,43	58,10	67,17	58,39	66,92	58,68	66,66	58,98	66,40	59,26	89
57,85	68,69	58,15	68,44	58,45	68,18	58,76	67,92	59,05	67,67	59,34	67,41	59,64	67,15	59,93	90
58,49	69,45	58,80	69,19	59,10	68,94	59,40	68,68	59,70	68,42	60,00	68,16	60,28	67,89	60,00	91
59,14	70,22	59,44	69,96	59,75	69,70	60,05	69,43	60,36	69,17	60,66	68,90	60,86	68,66	61,26	92
59,78	70,98	60,09	70,72	60,40	70,46	60,71	70,19	61,01	69,92	61,32	69,65	61,53	69,38	61,93	93
60,42	71,74	60,74	71,48	61,05	71,20	61,36	70,94	61,67	70,67	61,98	70,40	62,19	70,13	62,59	94
61,07	72,51	61,38	72,24	61,70	71,96	62,01	71,78	62,33	71,43	62,64	71,15	62,85	70,88	63,26	95
61,71	73,27	62,02	73,00	62,35	72,72	62,67	72,45	62,98	72,18	63,30	71,90	63,51	71,62	63,93	96
62,35	74,03	62,67	73,76	63,00	73,48	63,32	73,20	63,64	72,93	63,96	72,65	64,18	72,37	64,59	97
63,00	74,80	63,33	74,52	63,65	74,24	63,97	73,96	64,29	73,68	64,01	73,10	64,84	73,11	65,25	98
63,64	75,56	63,97	75,28	64,29	74,99	64,63	74,72	64,95	74,43	65,27	74,15	65,50	73,85	65,92	99
64,28	76,32	64,61	76,04	64,95	75,76	65,28	75,47	65,61	75,18	95,94	74,90	66,26	74,61	66,59	100
64,92	77,09	65,26	76,80	65,59	76,52	65,93	76,23	66,26	75,94	66,59	75,65	66,93	75,35	67,2	101
65,57	77,85	65,90	77,56	66,24	77,27	66,58	76,98	66,92	76,69	67,25	76,39	67,59	76,10	67,92	102
66,21	78,61	66,55	78,32	66,89	78,03	67,24	77,74	67,57	77,44	67,91	77,14	68,25	76,84	68,59	103
66,85	79,38	67,20	79,09	67,54	78,79	67,89	78,49	68,23	78,19	68,57	77,89	68,92	77,59	69,25	104
67,49	80,14	67,84	79,85	68,19	79,55	68,54	79,25	68,88	78,94	69,23	78,64	69,58	78,33	69,92	105
68,14	80,90	68,49	80,61	68,84	80,31	69,19	80,00	69,54	79,70	69,89	79,39	70,24	79,08	70,58	106
68,78	81,66	69,13	81,37	69,49	81,06	69,85	80,76	70,20	80,45	70,55	80,14	70,91	79,83	71,25	107
69,42	82,43	69,78	82,1	70,14	81,82	70,50	81,51	70,8	81,20	71,21	80,89	71,57	80,57	71,92	108
70,07	83,19	70,43	82,89	70,79	82,58	71,15	82,66	71,51	81,95	71,87	81,64	72,23	81,32	72,58	109
70,71	83,96	71,07	83,65	71,44	83,33	71,80	83,08	72,17	82,70	72,53	82,39	72,89	82,07	73,25	110
71,36	84,72	71,72	84,41	72,09	84,09	72,46	83,77	72,82	83,45	73,19	83,14	73,55	82,81	73,91	111
71,99	85,48	72,37	85,17	72,74	84,85	73,11	84,53	73,48	84,21	73,83	83,88	74,21	83,56	74,58	112
72,64	86,24	73,01	85,93	73,39	85,61	73,76	85,28	74,14	84,96	74,51	84,64	74,88	84,31	75,25	113
73,28	87,01	73,66	86,69	74,04	86,37	74,42	86,04	74,79	85,71	75,17	85,39	75,54	85,05	75,91	114
73,92	87,78	74,30	87,45	74,68	87,12	75,07	86,79	75,45	86,46	75,88	86,14	76,20	85,80	76,58	115
74,57	88,53	74,96	88,21	75,33	87,88	75,72	87,55	76,10	87,21	76,48	86,88	76,87	86,54	77,34	116
75,21	89,30	75,60	88,97	75,98	89,64	76,38	88,30	76,76	87,97	77,14	87,63	77,53	87,29	78,01	117
75,8	90,06	76,13	89,73	76,63	90,39	77,03	89,06	77,42	88,72	77,80	88,38	78,19	88,04	78,68	118
76,49	90,82	76,78	90,49	77,28	90,15	77,68	89,81	78,07	89,47	78,46	89,13	78,80	88,78	79,34	119
77,14	91,59	77,53	91,25	77,93	90,91	78,33	90,56	78,73	90,22	79,12	89,88	79,51	89,53	79,91	120
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat	Distance
Min.	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
Deg.	49 Degrees								48 Degrees						

Distance	42 Degrees								43 Degrees							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 M
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
1	0,74	0,67	0,74	0,67	0,74	0,68	0,73	0,68	0,73	0,68	0,73	0,68	0,72	0,69	0,72
2	1,49	1,34	1,48	1,34	1,47	1,35	1,47	1,36	1,46	1,36	1,46	1,37	1,45	1,38	1,44
3	2,23	2,07	2,22	2,02	2,21	2,03	2,20	2,04	2,19	2,05	2,18	2,06	2,18	2,06	2,17
4	2,97	2,68	2,96	2,69	2,95	2,70	2,94	2,71	2,92	2,73	2,93	2,74	2,90	2,75	2,89
5	3,72	3,35	3,70	3,36	3,69	3,38	3,67	3,39	3,66	3,41	3,64	3,43	3,63	3,44	3,61
6	4,46	4,01	4,44	4,03	4,42	4,05	4,41	4,07	4,39	4,09	4,37	4,11	4,35	4,13	4,33
7	5,20	4,68	5,18	4,71	5,16	4,73	5,14	4,75	5,12	4,77	5,10	4,80	5,08	4,82	5,06
8	5,94	5,35	5,92	5,38	5,90	5,40	5,87	5,43	5,85	5,46	5,83	5,48	5,80	5,51	5,78
9	6,69	6,02	6,66	6,05	6,64	6,08	6,61	6,11	6,58	6,14	6,55	6,17	6,53	6,19	6,50
10	7,43	6,69	7,40	6,72	7,37	6,76	7,34	6,79	7,31	6,82	7,28	6,85	7,25	6,88	7,22
11	8,17	7,36	8,14	7,40	8,11	7,43	8,08	7,47	8,04	7,50	8,01	7,54	7,98	7,57	7,95
12	8,92	8,03	8,88	8,07	8,85	8,11	8,81	8,15	8,78	8,18	8,74	8,22	8,70	8,26	8,67
13	9,66	8,70	9,62	8,74	9,58	8,78	9,55	8,82	9,51	8,87	9,47	8,91	9,43	8,95	9,39
14	10,40	9,37	10,36	9,41	10,32	9,46	10,28	9,50	10,24	9,55	10,20	9,59	10,15	9,64	10,11
15	11,15	10,04	11,10	10,08	11,06	10,13	11,01	10,18	10,97	10,23	10,92	10,28	10,88	10,32	10,83
16	11,89	10,71	11,84	10,76	11,79	10,81	11,75	10,86	11,70	10,91	11,65	10,96	11,60	11,01	11,56
17	12,63	11,37	12,58	11,43	12,53	11,49	12,48	11,54	12,43	11,59	12,38	11,65	12,33	11,70	12,28
18	13,38	12,04	13,32	12,10	13,27	12,16	13,22	12,22	13,16	12,28	13,11	12,33	13,05	12,39	13,00
19	14,12	12,71	14,06	12,77	14,01	12,84	13,96	12,90	13,89	12,96	13,84	13,02	13,78	13,08	13,72
20	14,86	13,38	14,80	13,45	14,75	13,51	14,69	13,58	14,63	13,64	14,57	13,70	14,51	13,77	14,45
21	15,61	14,05	15,54	14,12	15,58	14,19	15,42	14,25	15,36	14,32	15,29	14,39	15,23	14,45	15,17
22	16,35	14,72	16,28	14,79	16,22	14,86	16,15	14,93	16,09	15,00	16,02	15,07	15,96	15,14	15,89
23	17,09	15,39	17,02	15,46	16,96	15,54	16,89	15,61	16,82	15,69	16,75	15,76	16,68	15,83	16,61
24	17,83	16,06	17,76	16,13	17,79	16,22	17,62	16,29	17,55	16,37	17,48	16,44	17,41	16,52	17,33
25	18,58	16,73	18,50	16,81	18,43	16,89	18,36	16,97	18,28	17,05	18,21	17,13	18,13	17,21	18,06
26	19,32	17,40	19,24	17,47	19,17	17,57	19,09	17,65	19,01	17,73	18,94	17,81	18,86	17,89	18,77
27	20,06	18,07	19,98	18,15	19,91	18,24	19,82	18,33	19,74	18,41	19,66	18,50	19,58	18,58	19,50
28	20,81	18,73	20,72	18,82	20,64	18,92	20,56	19,01	20,47	19,10	20,39	19,18	20,31	19,27	20,22
29	21,55	19,40	21,46	19,49	21,38	19,60	21,29	19,69	21,21	19,78	21,12	19,87	21,03	19,96	20,94
30	22,29	20,07	22,21	20,17	22,12	20,27	22,03	20,36	21,94	20,46	23,85	20,55	21,76	20,65	21,67
31	23,04	20,74	22,95	20,84	22,85	20,94	22,76	21,04	22,67	21,14	22,58	21,24	22,49	21,34	22,39
32	23,78	21,41	23,69	21,51	23,59	21,62	23,50	21,72	23,40	21,82	23,30	21,92	23,21	22,03	23,11
33	24,52	22,08	24,43	22,19	24,33	22,30	24,23	22,40	24,13	22,51	24,02	22,61	23,94	22,71	23,84
34	25,27	22,75	25,17	22,86	25,07	22,96	24,97	23,08	24,86	23,19	24,75	23,29	24,66	23,40	24,56
35	26,01	23,42	25,91	23,53	25,80	23,64	25,70	23,76	25,60	23,87	25,48	23,98	25,39	24,09	25,28
36	26,75	24,09	26,65	24,20	26,54	24,31	26,43	24,44	26,32	24,55	26,21	24,66	26,11	24,78	26,00
37	27,49	24,76	27,39	24,87	27,28	24,99	27,17	25,19	27,06	25,23	26,94	25,35	26,84	25,47	26,73
38	28,24	25,43	28,13	25,55	28,01	25,67	27,90	25,82	27,79	25,91	27,66	25,93	27,56	26,16	27,45
39	28,98	26,09	28,87	26,22	28,75	26,34	28,64	26,50	28,52	26,60	28,39	26,62	28,29	26,84	28,18
40	29,73	26,76	29,61	26,89	29,49	27,02	29,37	27,15	29,25	27,28	29,13	27,41	29,01	27,53	28,89
41	30,47	27,43	30,35	27,57	30,23	27,70	30,11	27,83	29,98	27,96	29,86	28,09	29,74	28,22	29,62
42	31,21	28,10	31,09	28,24	30,96	28,38	30,84	28,51	30,72	28,64	30,59	28,78	30,46	28,91	30,34
43	31,95	28,77	31,83	28,91	31,69	29,05	31,57	29,19	31,45	29,33	31,32	29,46	31,19	29,60	31,06
44	32,70	29,44	32,57	29,58	32,43	29,73	32,31	29,87	32,18	30,01	32,05	30,15	31,91	30,29	31,78
45	33,44	30,10	33,31	30,25	33,17	30,40	33,04	30,55	32,91	30,69	32,77	30,83	32,64	30,97	32,50
46	34,18	30,77	34,05	30,93	33,90	31,08	33,78	31,33	33,64	31,37	33,50	31,52	33,36	31,66	33,23
47	34,93	31,44	34,79	31,60	34,64	31,76	34,51	31,90	34,37	32,05	34,23	32,20	34,09	32,35	33,95
48	35,67	32,11	35,53	32,27	35,38	32,43	35,24	32,58	35,10	32,74	34,96	32,89	34,82	33,04	34,67
49	36,41	32,78	36,27	32,94	36,11	33,11	35,98	33,26	35,83	33,42	35,69	33,57	35,54	33,73	35,39
50	37,16	33,46	37,01	33,62	36,86	33,78	36,72	33,94	36,57	34,10	36,42	34,26	36,27	34,42	36,12
51	37,90	34,13	37,75	34,29	37,60	34,46	37,45	34,62	37,30	34,78	37,15	34,94	36,99	35,11	36,84
52	38,64	34,79	38,49	34,96	38,34	35,13	38,18	35,30	38,03	35,46	37,87	35,63	37,72	35,79	37,56
53	39,39	35,46	39,23	35,63	39,07	35,81	38,92	35,98	38,76	36,15	38,60	36,31	38,44	36,48	38,28
54	40,13	36,13	39,97	36,31	39,81	36,48	39,65	36,66	39,49	36,83	39,33	37,00	39,17	37,17	39,01
55	40,87	36,80	40,71	36,98	40,55	37,16	40,39	37,33	40,22	37,51	40,06	37,68	39,89	37,86	39,73
56	41,61	37,47	41,45	37,65	41,29	37,84	41,12	38,01	40,95	38,19	40,79	38,37	40,62	38,55	40,45
57	42,36	38,14	42,19	38,32	42,02	38,51	41,85	38,69	41,68	38,87	41,51	39,05	41,34	39,23	41,16
58	43,10	38,81	42,93	38,99	42,76	39,19	42,59	39,37	42,42	39,56	42,24	39,74	42,07	39,92	41,89
59	43,84	39,48	43,67	39,67	43,50	39,86	43,32	40,05	43,15	40,24	42,97	40,42	42,78	40,61	42,62
60	44,59	40,15	44,41	40,34	44,24	40,53	44,06	40,73	43,88	40,92	43,70	41,11	43,52	41,30	43,34
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 M
	48 Deg		47 Degrees								46 Degrees				

42 Degrees								43 Degrees								Distance
Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
t.	Dep.	Lat.	Dep	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
33	40,82	45,15	41,01	44,97	41,21	44,79	41,44	44,61	41,60	44,43	41,80	44,25	41,99	44,06	42,18	61
07	41,49	45,89	41,69	45,71	41,89	45,53	42,09	45,34	42,28	45,16	42,48	44,97	42,68	44,79	42,87	62
32	42,15	46,63	42,36	46,45	42,56	46,26	42,76	46,07	42,97	45,89	43,17	45,70	43,36	45,51	43,57	63
56	42,82	47,37	43,03	47,18	43,23	46,99	43,44	46,80	43,65	46,61	43,85	46,42	44,05	46,23	44,26	64
30	43,49	48,11	43,70	47,92	43,91	47,73	44,12	47,54	44,33	47,34	44,54	47,15	44,74	46,95	44,95	65
05	44,16	48,85	44,37	48,66	44,58	48,46	44,80	48,27	45,01	48,07	45,22	47,87	45,43	47,67	45,64	66
79	44,83	49,59	45,05	49,40	45,26	49,20	45,48	49,00	45,69	48,80	45,91	48,60	46,12	48,40	46,33	67
53	45,50	50,83	45,72	50,13	45,93	49,93	46,16	49,73	46,38	49,53	46,59	49,32	46,80	49,12	47,03	68
27	46,17	51,07	46,40	50,87	46,61	50,66	46,84	50,46	47,06	50,25	47,28	50,05	47,49	49,84	47,72	69
02	46,84	51,81	47,07	51,61	47,29	51,40	47,52	51,19	47,74	50,99	47,96	50,78	48,18	50,56	48,41	70
76	47,51	52,55	47,74	52,35	47,97	52,14	48,19	51,93	48,42	51,71	48,65	51,50	48,87	51,29	49,10	71
51	48,18	53,29	48,41	53,08	48,64	52,87	48,87	52,66	49,10	52,44	49,33	52,23	49,56	52,01	49,79	72
25	48,85	54,03	49,08	53,82	49,32	53,60	49,55	53,39	49,79	53,17	50,02	52,95	50,25	52,73	50,48	73
99	49,51	54,77	49,75	54,56	49,99	54,34	50,23	54,42	50,47	53,90	50,70	53,68	50,94	53,45	51,17	74
73	50,18	55,51	50,43	55,29	50,67	55,07	50,91	54,85	51,15	54,63	51,39	54,40	51,62	54,17	51,87	75
48	50,85	56,25	51,10	56,03	51,35	55,81	51,59	55,58	51,83	55,35	52,07	55,13	52,31	54,90	52,56	76
22	51,52	56,99	51,77	56,77	52,02	56,54	52,27	56,31	52,51	56,08	52,76	55,85	53,00	55,62	53,25	77
96	52,19	57,73	52,44	57,51	52,70	57,27	52,95	57,04	53,20	56,81	53,44	56,58	53,69	56,34	33,94	78
71	52,86	58,47	53,11	58,24	53,37	58,01	53,63	57,77	53,88	57,54	54,13	57,30	54,38	57,06	54,63	79
45	53,53	59,22	53,79	58,98	54,05	58,75	54,30	58,51	54,56	58,27	54,81	58,03	55,07	57,79	55,32	80
19	54,20	59,96	54,46	59,72	54,72	59,48	54,98	59,24	55,24	59,00	55,50	58,75	55,76	58,51	56,01	81
94	54,87	60,70	55,13	60,46	55,40	60,21	55,66	59,97	55,92	59,73	56,18	59,48	56,44	59,23	56,70	82
68	55,54	61,44	55,81	61,19	56,07	60,95	56,34	60,70	56,61	60,45	56,87	60,20	57,13	59,95	57,40	83
42	56,21	62,18	56,48	61,93	56,75	61,68	57,02	61,43	57,29	61,18	57,55	60,92	57,82	60,68	58,08	84
17	56,87	62,92	57,15	62,67	57,43	62,42	57,70	62,16	57,97	61,91	58,23	61,65	58,51	61,40	58,78	85
91	57,51	63,66	57,82	63,40	58,10	63,15	58,38	62,89	58,65	62,64	58,92	62,38	59,20	62,12	59,47	86
65	58,21	64,40	58,49	64,14	58,78	63,88	59,06	63,62	59,33	63,37	59,61	63,10	59,88	62,84	60,16	87
39	58,88	65,14	59,17	64,88	59,46	64,62	59,74	64,36	60,02	64,09	60,29	63,83	60,57	63,56	60,86	88
14	59,55	65,88	59,84	65,61	60,13	65,35	60,41	65,09	60,70	64,82	60,98	64,55	61,26	64,29	61,55	89
88	60,22	66,62	60,51	66,35	60,80	66,09	61,09	65,82	61,38	65,55	61,67	65,28	61,95	65,01	62,24	90
63	60,89	67,36	61,18	67,09	61,48	66,82	61,77	66,55	62,06	66,28	62,35	66,01	62,64	65,73	62,93	91
37	61,56	68,10	61,86	67,83	62,15	67,56	62,45	67,28	62,74	67,01	63,04	66,73	63,33	66,46	63,62	92
11	62,23	68,84	62,53	68,57	62,83	68,29	63,13	68,01	63,43	67,74	63,72	67,46	64,02	67,18	64,31	93
85	62,90	69,58	63,20	69,30	63,51	69,02	63,81	68,75	64,11	68,46	64,41	68,18	64,70	67,90	65,00	94
60	63,57	70,32	63,87	70,04	64,18	69,76	64,49	69,48	64,79	69,19	65,09	68,91	65,39	68,62	65,70	95
34	64,24	71,06	64,54	70,78	64,86	70,49	65,17	70,21	65,47	69,92	65,78	69,63	66,08	69,34	66,39	96
08	64,90	71,80	65,22	71,51	65,53	71,23	65,84	70,94	66,15	70,64	66,46	70,36	66,77	70,07	67,08	97
83	65,57	72,54	65,89	72,25	66,21	71,96	66,52	71,67	66,84	71,38	67,15	71,08	67,46	70,79	67,77	98
57	66,24	73,28	66,56	72,99	66,89	72,69	67,20	72,40	67,52	72,10	67,83	71,81	68,14	71,51	68,46	99
31	66,91	74,02	67,24	73,73	67,56	73,43	67,88	73,13	68,20	72,84	68,52	72,54	68,83	72,24	69,15	100
06	67,58	74,76	67,91	74,46	68,23	74,17	68,56	73,87	68,88	73,56	69,20	73,26	69,52	72,96	69,84	101
80	68,25	75,50	68,58	75,20	68,90	74,90	69,24	74,60	69,56	74,29	69,89	73,99	70,21	73,68	70,53	102
54	68,92	76,24	69,25	75,94	69,58	75,63	69,92	75,33	70,25	75,02	70,57	74,71	70,90	74,40	71,23	103
29	69,59	76,98	69,92	76,68	70,26	76,37	70,60	76,06	70,93	75,75	71,26	75,44	71,57	75,12	71,92	104
03	70,26	77,72	70,60	77,41	70,93	77,10	71,27	76,79	71,61	76,48	71,94	76,16	72,25	75,84	72,61	105
77	70,93	78,46	71,27	78,15	71,60	77,84	71,95	77,52	72,39	77,20	72,63	76,89	72,94	76,57	73,30	106
51	71,5	79,20	71,94	78,89	72,28	78,57	72,63	78,25	73,07	77,93	73,31	77,61	73,63	77,29	73,99	107
26	72,26	79,94	72,62	79,63	72,96	79,30	73,31	78,98	73,76	78,68	74,00	78,34	74,32	78,01	74,69	108
00	72,93	80,68	73,29	80,36	73,63	80,04	73,99	79,71	74,44	79,41	74,68	79,06	75,01	78,73	75,38	109
74	73,60	81,42	73,96	81,10	74,31	80,77	74,67	80,45	75,02	80,12	75,37	79,79	75,71	79,16	76,07	110
49	74,27	82,16	74,63	81,84	74,99	81,51	75,35	81,18	75,70	80,85	76,05	80,82	76,41	80,18	76,75	111
23	74,94	82,90	75,30	82,57	75,67	82,24	76,03	81,91	76,38	81,58	76,74	81,24	77,09	80,90	77,46	112
97	75,61	83,64	75,98	83,31	76,34	82,98	76,70	82,64	77,07	82,30	77,42	81,97	77,78	81,63	78,14	113
72	76,28	84,38	76,65	84,05	77,02	83,71	77,38	83,37	77,75	83,03	78,11	82,69	78,47	82,35	78,83	114
46	76,95	85,12	77,32	84,79	77,69	84,44	78,06	84,10	78,43	83,76	78,79	83,42	79,16	83,07	79,53	115
20	77,62	85,86	77,99	85,52	78,37	85,18	78,74	84,83	79,11	84,49	79,48	84,13	79,85	83,79	80,22	116
95	78,28	86,60	78,66	86,26	79,07	85,91	79,42	85,57	79,79	85,22	80,17	84,86	80,54	84,51	80,92	117
69	78,95	87,34	79,34	86,99	79,74	86,65	80,10	86,30	80,48	85,95	80,85	85,58	81,22	85,24	81,60	118
43	79,63	88,08	80,01	87,73	80,42	87,38	80,78	87,03	81,16	86,67	81,54	86,31	81,91	85,96	82,29	119
18	80,30	88,83	80,68	88,47	81,07	88,12	81,46	87,76	81,84	87,40	82,22	87,04	82,60	86,68	82,98	120
	Lat	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min		15 Min.		
Deg.		47 Degrees								46 Degrees						

Distance	44 Degrees						45 Deg.		44 Degrees						45 I
	0 Min.		20 Min.		40 Min.		0 Min.		0 Min.		20 Min.		40 Min.		0 M
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.
1	0,72	0,69	0,72	0,70	0,71	0,70	0,71	0,71	43,88	42,37	43,63	42,63	43,38	42,88	43,13
2	1,44	1,39	1,43	1,40	1,42	1,41	1,41	1,41	44,60	43,09	44,35	43,33	44,09	43,58	43,84
3	2,16	2,08	2,15	2,10	2,13	2,11	2,12	2,12	45,32	43,86	45,06	44,03	44,81	44,29	44,55
4	2,88	2,78	2,86	2,79	2,84	2,81	2,83	2,83	46,04	44,46	45,78	44,73	45,52	44,99	45,25
5	3,60	3,47	3,58	3,49	3,56	3,51	3,53	3,53	46,75	45,15	46,49	45,42	46,23	45,69	45,96
6	4,32	4,17	4,29	4,19	4,27	4,22	4,24	4,24	47,47	45,85	47,21	46,12	46,94	46,40	46,67
7	5,03	4,86	5,01	4,89	4,98	4,92	4,95	4,95	48,19	46,54	47,92	46,82	47,55	47,10	47,38
8	5,75	5,56	5,72	5,59	5,69	5,62	5,66	5,66	48,91	47,24	48,64	47,52	48,36	47,80	48,08
9	6,47	6,25	6,44	6,29	6,40	6,33	6.36	6,36	49,63	48,93	49,35	48,22	49,08	48,50	48,79
10	7,19	6,95	7,15	6,99	7,11	7,03	7,07	7,07	50,35	48,63	50,07	48,92	49,78	49,21	49,50
11	7,91	7,64	7,87	7,69	7,82	7,73	7,78	7,78	51,07	49,32	50,78	49,62	50,43	49,91	50,20
12	8,63	8,34	8,58	8,39	8,53	8,44	8,49	8,49	51,79	50,02	51,50	50,32	51,21	50,61	50,91
13	9,35	9,03	9,30	9,08	9,25	9,14	9,19	9,19	52,81	50,71	52,21	51,01	51,91	51,32	51,62
14	10,07	9,73	10,01	9,78	9,96	9,84	9,90	9,90	53,53	51,41	52,93	51,71	52,63	52,02	52,33
15	10,79	10,42	10,73	10,48	10,67	10,54	10,61	10,61	54,25	52,10	53,64	52,41	53,34	52,72	53,03
16	11,51	11,12	11,44	11,18	11,38	11,25	11,31	11,31	54,97	52,80	54,36	53,11	54,05	53,42	53,74
17	12,23	11,81	12,16	12,88	12,09	11,95	12,02	12,02	55,69	53,49	55,07	53,81	54,76	54,13	54,45
18	12,94	12,51	12,87	12,57	12,70	12,65	12,73	12,73	56,41	54,29	55,79	54,51	55,47	54,83	55,15
19	13,65	13,20	13,59	13,27	13,41	13,36	13,43	13,43	57,12	54,98	56,50	55,21	56,18	55,53	55,86
20	14,39	13,89	14,31	13,98	14,22	14,06	14,14	14,14	57,55	55,57	57,22	55,91	56,90	56,24	56,57
21	15,11	14,59	15,02	14,68	14,93	14,76	14,85	14,85	58,27	56,27	57,94	56,60	57,61	56,94	57,28
22	15,82	15,28	15,74	15,37	15,65	15,46	15,56	15,56	58,98	56,96	58,65	57,30	58,32	57,64	57,98
23	16,54	15,98	16,45	16,07	16,36	16,17	16,26	16,26	59,70	57,66	59,37	58,00	59,03	58,35	58,69
24	17,26	16,67	17,17	16,77	17,07	16,87	16,97	16,97	60,42	58,35	60,08	58,70	59,74	59,05	59,40
25	17,98	17,37	17,88	17,47	17,78	17,57	17,68	17,68	61,14	59,05	60,80	59,40	60,45	59,75	60,10
26	18,70	18,00	18,60	18,17	18,49	18,28	18,38	18,38	61,86	59,74	61,51	60,10	61,16	60,45	60,81
27	19,42	18,76	19,31	18,87	19,20	18,98	19,09	19,09	62,58	60,44	62,23	60,80	61,87	61,16	61,52
28	20,14	19,45	20,03	19,57	19,91	19,68	19,80	19,80	63,30	61,13	62,94	61,50	62,58	61,86	62,22
29	20,86	20,15	20,74	20,27	20,62	20,39	20,51	20,51	64,02	61,83	63,66	62,20	63,30	62,56	62,93
30	21,58	20,84	21,46	20,96	21,34	21,09	21,21	21,21	64,74	62,52	64,38	62,89	64,01	63,27	63,64
31	22,30	21,53	22,17	21,06	22,0	21,79	21,92	21,92	65,46	63,21	65,09	63,59	64,72	63,97	64,35
32	23,02	22,23	22,89	21,76	22,76	22,49	22,63	22,63	66,18	64,01	65,81	64,29	65,43	64,67	65,05
33	23,74	22,92	23,60	22,46	23,47	23,20	23,33	23,33	66,90	64,70	66,52	64,99	66,14	65,37	65,76
34	24,46	23,62	24,32	23,16	24,18	23,90	24,04	24,04	67,62	65,40	67,24	65,68	66,85	66,08	66,47
35	25,17	24,31	25,03	23,86	24,89	24,60	24,75	24,75	68,34	66,09	67,95	66,39	67,56	66,78	67,17
36	25,89	25,01	25,75	24,56	25,60	25,31	25,46	25,46	69,05	66,79	68,67	67,09	68,27	67,48	67,88
37	26,61	25,71	26,46	25,26	26,31	26,01	26,16	26,16	69,77	67,48	69,38	67.79	68,99	68,19	68,59
38	27,33	26,41	27,18	25,94	27,02	26,71	26,87	26,87	70,49	68,18	70,10	68,49	69,70	68,89	69,30
39	28,05	27,10	27,89	26,66	27,73	27,42	27,58	27,58	71,21	68,87	70,81	69,19	70.41	69,59	70,00
40	28,77	27,79	28,61	27,95	28,45	28,12	28,28	28,28	71,93	69,47	71,53	69,88	71,12	70,30	70,71
41	29,49	28,48	29,33	28,65	29,16	28,82	28,99	28,99	72,65	70,16	72,24	70,58	71,83	71,00	71,42
42	30,21	29,18	30,04	29,35	29,87	29,52	29,70	29,70	73,37	70,86	72,96	71,28	72,54	71,70	72,12
43	30,93	29,87	30,76	30,05	30,58	30,23	30,41	30,41	74,09	71,55	73,67	71,98	73,25	72,40	72,83
44	31,65	30,57	31,47	30,75	31,29	30,93	31,11	31,11	74,81	72,25	74,39	72,68	73,96	73,11	73,54
45	32,37	31,26	32,19	31,43	32,00	31,63	31,82	31,82	75,53	72,94	75,10	73,38	74,68	73,81	74,25
46	33,09	31,96	32,90	32,14	32,71	32,34	32,53	32,53	76,25	73,64	75,82	74,08	75,39	74,51	74,95
47	33,81	32,65	33,62	32,84	33,43	33,04	33,23	33,23	76,97	74,33	76,53	74,78	76,10	75,22	75,66
48	34,53	33,35	34,33	33,54	34,14	33,74	33,94	33,94	77,69	75,03	77,25	75,47	76,81	75,92	76,37
49	35,24	34,04	35,05	34,24	34,85	34,44	34,65	34,65	78,40	75,72	77,96	76,17	77,52	76,62	77,07
50	35,97	34,73	35,76	34,94	35,56	35,15	35,35	35,35	79,13	76,41	78,68	76,87	78,23	77,33	77,78
51	36,69	35,43	36,48	35,64	36,27	35,85	36,06	36,06	79,85	77,12	79,40	77,57	78,95	78,04	78 49
52	37,40	36,12	37,19	36,34	36,98	36,55	36,77	36,77	80,56	77,80	80,11	78,27	79,65	78,74	79,20
53	38,12	36,82	37,91	37,04	37,69	37,26	37,47	37,47	81,28	78,50	80,83	78,97	80,37	79,43	79,90
54	38,84	37,51	38,62	37,74	38,40	37,96	38,18	38,18	82,00	79,19	81,54	79,67	81,08	80,11	80,61
55	39,56	38,21	39,34	38,44	39,12	38,66	38,89	38,89	82,72	79,89	82,26	80,37	81,79	80,85	81,32
56	40,28	38,90	40,05	39,14	39,82	39,37	39,59	39,59	83,44	80,58	82,97	81,06	82,50	81,55	82,02
57	41,01	39,60	40,77	39,84	40,54	40,07	40,30	40,30	84,16	81,28	83,69	81,76	83,21	82,26	82,73
58	41,72	40,29	41,48	40,53	41,25	40,77	41,01	41,01	84,88	81,97	84,40	82,46	83,92	82,96	83,44
59	42,44	40,99	42,20	41,23	41,96	41,48	41,72	41,72	85,60	82,67	85,12	83,16	84,68	83,06	84,14
60	43,16	41,83	42,92	41,93	42,67	42,18	42,43	42,43	86,32	83,36	85,83	83,86	85,34	84,35	84,85
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
	0 Min.		40 Min.		20 Min.		0 Min.		0 Min.		40 Min.		20 Min.		0 M
	46 Deg.		45 Degrees						46 Deg.		45 Degrees				

THE

ELEMENTS

OF

NAVIGATION;

CONTAINING THE

THEORY and PRACTICE.

With all the neceſſary TABLES.

To which is added,

A TREATISE of

Marine Fortification.

For the USE of the ROYAL MATHEMATICAL SCHOOL at
CHRIST'S HOSPITAL, and the GENTLEMEN of the NAVY.

VOL. II.

By J. ROBERTSON, F.R.S.
Mathematical Maſter at CHRIST'S HOSPITAL.

LONDON,
Printed for J. NOURSE, at the *Lamb*, oppoſite *Katherine-Street*, in the *Strand*. MDCCLIV.

THE ELEMENTS OF NAVIGATION.

Lately publiſhed by J. Nourse,

In One Volume in Octavo,

(Price 6 s. bound)

The Elements of Astronomy;

With practical rules, whereby the principal phænomena ar
determined,

To which is annexed,

A Treatise of Projection in general, and the computati
ons thence ariſing, and in particular, the calculation fror
projections peculiar to eclipſes of the ſun, and to occultation
of the fixed ſtars by the moon.

Deſigned for Students in Univerſities,

The whole tranſlated from the French of M. DE LA CAILL
Member of the Royal Academy of Sciences at Paris,

By JOHN ROBERTSON, F. R. S.

With Additions and Corrections communicated by the Author,

THE ELEMENTS OF NAVIGATION.

BOOK VII.

OF GLOBULAR SAILING.

SECTION I.

Definitions and Principles.

3. BY Globular ſailing, is meant the manner of eſtimating either the difference of latitude, difference of longitude, departure, urſe or diſtance, from any two of them being known, upon princis deduced from the ſpherical figure of the earth.

In the preceding parts of ſailing, the operations were performed as if t courſes and diſtances of ſhips had been run on a plane, or flat ſurface: t that this cannot be true, appears from what was ſaid in art. 553. o which, as a farther proof, there may be added, that mariners, as they l from northern or ſouthern latitudes towards the equator, obſerve the ſtars aut the poles conſtantly to diminiſh their altitude or height above the appent horizon: It is alſo well known, that in eclipſes of the moon, the dkened part is bounded by a circular curve; and conſequently, the body ich caſts the ſhade, or obſtructs the light, muſt be bounded by a like ve: But as this obſcuration is cauſed by the earth, conſequently its ſace muſt be limited by a circular figure, that is, it muſt be globular.

714. As the meridians are circles on this globe, meeting in the po it is obvious that any two of theſe circles muſt recede more from another at greater diſtances from the poles; and at equal diſtances fr both poles, or at the equator, the diſtance between the meridians is greateſt.

The true place of a ſhip at ſea, depends both upon its diſta from the equator, and from ſome noted meridian; and becauſe the ridional diſtance, that is, the diſtance between two meridians, varie every latitude; therefore it is convenient this diſtance ſhould be recko in a fixed latitude, and where the degrees are of the ſame magnit with thoſe of the meridian, which can be no where but at the equa where 60 nautical miles make a degree.

715. Now a ſhip ſailing from any latitude upon an oblique rhu until ſhe has made a known departure, will, by the rules of plane ing, reckon herſelf under the ſame meridian, whether ſhe ſails to northward or ſouthward: But from what has been ſaid, this cannot true; for the ſame meridional diſtance, which in this caſe is take departure, will not ſerve two different latitudes on the ſame ſide of equator: Therefore the common methods of plane ſailing alone, are ſufficient to ſhew the ſhip's true place, a neceſſary correction b wanted with reſpect to her longitude.

This incorrect method of plane ſailing was founded on the ma in which the ſea charts were at firſt conſtructed: For it being the convenient way to repreſent the meridians, parallels of latitude, rhumb lines in ſuch charts by right lines, where the meridians ſh be parallel, and the eaſt and weſt lines cut them at right angles: Co quently the diſtances of the meridians in every parallel were equa their diſtances at the equator; and a degree on any parallel of latit as large as a degree on the equator; whereby each degree of longitu thoſe parallels was increaſed beyond its juſt ſize, in proportion a equator, or its radius, is greater than the parallel, or its radius.

716. Now to remove theſe material objections againſt the ſea ch a different method of conſtruction ſhould be uſed; and it had hinted, ſome hundred years ſince, by ſeveral perſons, that the degre latitude in ſuch charts ſhould be lengthened as they approach the p and accordingly, about the year 1550, the firſt chart of this kind publiſhed by Mr. *Gerrard Mercator* a Fleming; wherein the degre latitude were gradually lengthened from the equator towards the p but in what manner, or how the chart was conſtructed, he did ſhew.

717. About the year 1590 Mr. *Edward Wright* an Engliſhman d vered the true principles upon which ſuch a chart ſhould be conſtruc which was to increaſe the degrees of latitude as they approached poles, in the ſame proportion as the degrees of longitude between two meridians decreaſed on the globes: But it was not till the year

at he publiſhed his errors in Navigation; wherein he ſhews the prin-
ples of the true ſea chart, with the method of conſtructing it: Ne-
rtheleſs, the charts made on this conſtruction are called Mercator charts.

A true method of computing a ſhip's place at ſea does not appear to
ve been known till Mr. Wright publiſhed the ſaid book; therefore
ho' the chart may properly enough be called *Mercator*'s, yet the me-
od of ſailing called Mercator's, ſhould, in juſtice, be named from
r. *Wright*.

718. The difficulty in conſtructing a true ſea chart, ſeems to have
ſiſted in the finding a proper manner how to apply the ſurface of a
be to a plane, which Mr. *Wright* happily accompliſhed by a moſt in-
ious conception; the ſubſtance whereof is as follows.

ſt. Suppoſe a rectangular plane was rolled about the globe until the
es of the plane met, and formed a kind of concave cylinder incloſing
globe, and touching its equator.

d. Conceive the ſurface of this globe to ſwell (like a bladder while
s blowing up), from the equator towards the poles, proportionally in
tude as it does in longitude, until every part of its ſurface meets that
the concave cylinder, and thereon impreſs the lines that were drawn
the globular ſurface.

d. Then the cylinder, or rectangular plane, being unrolled, it will
reſent a ſea chart, whoſe parts bear the ſame proportion to one an-
er, as do the correſponding parts on the globe: But herein all the
es will be right lines.

or, in this formation of the nautical chart, every parallel of latitude
the globe will be increaſed till it is equal to the equator; and ſo the
ance of the meridians in thoſe parallels will become equal to their
ance at the equator; conſequently the meridians on the chart are ex-
ſſed by parallel right lines.

lſo, the meridians being lengthened as the parallels increaſed, every
ree of latitude is lengthened in the ſame proportion as the degrees
longitude are increaſed; therefore the diſtances of the parallels of la-
de become wider and wider as they approach the poles: But theſe pa-
els are alſo right lines.

gain. As the rhumb lines on the globe cut the meridians at equal
les, they will alſo on the chart cut the meridians at equal angles, and
ſequently be expreſſed by right lines; ſince none but right lines can
ſeveral parallel right lines, at equal angles.

The conſtruction of ſuch a chart, Mr. Wright deduced from the fol-
ing principles.

SECTION II.

Of the reckoning of longitude.

719. PROPOSITION I.

The diſtance between any two meridians at the equator,
Is in proportion to their diſtance in any parallel of latitude;
As the Radius,
To the coſine of that latitude.

DEMONSTRATION. See Fig. 1. Pl. VIII.

Let PDFE repreſent the fourth part of a ſphere; E being the cent P the pole, ED the radius of the equator, AB the radius of a parallel latitude: Then the arcs PBD, PC *d*, will each repreſent a quadrant of meridian; D *d* is an arc of the equator, and BC an arc of a parallel latitude; alſo the arc DB expreſſes the latitude, and PB the compleme of the latitude, whoſe right ſine is BA. (29

Now (262) the circumference of a circle whoſe radius is ED, is to t circumference of a circle whoſe radius is AB, as ED is to AB; that as the radius of the equator, to the radius of the parallel; or, as rad to the coſine of the latitude.

But like arcs are in the ſame ratio of their circumferences. (233, 26

And like arcs D *d*, BC, are intercepted between the ſame two meri ans; therefore

An arc of the equator, is to a like arc in any parallel of latitude;
As the Radius, to the coſine of that latitude.

720. COROL. Hence it is eaſy to conſtruct a table ſhewing, from t equator to the poles, the approach of two meridians in any latitude; in what proportion the degrees of longitude diminiſh in every latitude.

721. PROPOSITION II.

Any part of a parallel of latitude, is to a like part of a meridian, Radius to the ſecant of the lat. to that parallel.

DEMONSTRATION. See Fig. 2. Pl. VIII.

Let PDE repreſent a quadrant of a meridian, where P is the pole, DE the radius of the equator; AB is the radius of a parallel of l tude, or the coſine of the latitude whoſe ſine is BF, and ſecant EC.

Then EF : EB : : ED : EC. (3
Or coſ. lat. : Rad : : Rad : ſecant of the lat. to that parallel.
But coſ. lat. : Rad : : part of a parallel : like part of the equator. (7
Therefore, part of a parallel of latitude, is to a like part of the equat
As the Radius, is to the ſecant of the lat. to that parallel.
Now like parts of the meridian and equator are equal.
Therefore any part of a paral. of lat. is to a like part of a meridi
As Radius, to the ſecant of the lat. to that parallel.

7

2. PROPOSITION III.

The diſtance of any parallel of latitude (A) *from the equator, is ex-*
eſſed by the ſum of the ſecants of all the arcs between the equator and
at parallel.

DEMONSTRATION.

Now (721) As Radius, to the ſecant of the latitude A;
So is a diminiſh'd deg. long. in lat. A, or a degree of that parallel, to a
gree of the meridian.
But the degrees of latitude, or of the meridian, are to be lengthened
proportion as the degrees of longitude diminiſh. (717)
Therefore, As Radius, to the ſecant of the latitude A;
So is a natural deg. of the meridian, to a lengthened deg. in lat. A.
Here radius being as unity, and one natural deg. as unity alſo;
Therefore the length of a degree in any latitude, is as the ſecant of
at latitude, or may be expreſſed by that ſecant.
Now the diſtance of any parallel from the equator, is the ſum of all
e ſucceſſive arcs between the equator and that parallel.
Conſequently the diſtance of that parallel, is expreſſed by the ſum of
e ſecants of all theſe arcs between the equator and that parallel of
itude.

723. COR. Hence it appears, that by the addition of the ſecants of
all arcs, the diſtances of the parallels of latitude from the equator are
tained.
And theſe ſeveral diſtances, which are called *meridional parts*, being
ſpoſed in a table correſponding to the degrees and minutes in a quadrant,
rm a table of meridional parts.
And this was the excellent diſcovery of the celebrated Mr. *Wright*,
which the art of Navigation received greater improvements than by
hatever had been done before, the diſcovery of the mariner's compaſs
cepted; and indeed, in this and other things, he ſo far perfected the
t, that little elſe was wanted beſide an accurate method to find the
ngitude at ſea. And altho' there have been ſince his time many emi-
nt men who have done excellent things towards the rendering of Na-
gation more perfect, yet if the real uſe of ſuch things be ſtrictly con-
dered, it will, perhaps, be found that they amount to no more than
her methods of performing the uſeful operations; except what has been
one by Mr. *Richard Norwood* and Dr. *Halley*.

724. Mr. Wright made his table for the diviſion of the nautical me-
dian, or the table of meridional parts, as follows.
The meridional parts for 1 min. he made equal to the ſecant of 1 min.
The mer. parts to 2 m. equal to the ſum of the ſec. of 1 and 2 min.
The mer. parts to 3 m. equal to the ſum of the ſec. of 1, 2 and 3 min.
The mer. parts to 4 m. equal to the ſum of the mer. parts of 3 min.
nd the ſec. of 4 min.
And ſo on by a conſtant addition of the ſecants.

Now although a table thus made is abundantly ſufficient for all n tical uſes, yet had the ſecants of ſmaller parts than minutes been tak the table would have been more correct: And therefore Mr. Oughtr Sir Jonas Moore, Dr. Wallis, Dr. Halley, and others, have been induc to find methods of conſtructing theſe tables with more accuracy than the addition of the ſecants to every minute.

But a table of meridional parts conſtructed by the moſt accurate n thod, only ſhews that Mr. Wright's table does no where exceed the t meridian parts by half a minute, and this only near the pole; for latitudes as far as navigation is practicable, the difference is ſcare ſe ſible.

A table of meridional parts being obtained (ſee art. 827), the me dians and parallels of latitude for a ſea chart, wherein the ſituation places will bear the ſame proportion to one another as on the globe, m be conſtructed by the following

725. PROPOSITION IV.

To conſtruct a ſea chart which ſhall contain a given number of degrees latitude and longitude.

Suppoſe from the latitude of 23 degrees N. to the lat. of 59 degre N., and for to contain 80 degrees of weſt longitude from the meridi of London.

SOLUTION.

1ſt. Write the ſeveral included degrees of latitude orderly under o another in a column, the greateſt being uppermoſt.

2d. Then beginning at the lower one, againſt each degree write, another column, the differences between the meridional parts of the leſ latitude, and thoſe of the other given degrees of latitude.

3d. Divide each of theſe meridional parts by 60, ſetting the quotie againſt their reſpective dividends, in another column; and theſe will the meridional parts reduced to degrees of longitude, and expreſs t meaſures of the diviſions for the meridional degrees.

If the meridional parts to diviſions between the degrees were wante they are to be taken from the table of meridional parts in the ſa manner.

Theſe three articles are exemplified in the following table; whic altho' made to ſerve from the equator to 72 degrees of latitude, yet will ſerve for any intermediate limits, by ſubtracting the meridion degrees belonging to the latitude where the chart is to begin from thoſe of all the latitudes the chart is to contain; of the ſever remainders make a table, and theſe will be the numbers to be transferr to the chart, as ſhewn in what follows.

A TABI

A TABLE *for conſtructing a Mercator chart.*

Lat.	Mer. Parts	Mer. Deg.	Lat.	Mer. Parts	Mer. Deg.	Lat.	Mer. Parts	Mer. Deg.	Lat.	Mer. Parts	Mer. Deg.
72	6335	105,6	54	3865	64,4	36	2318	38,6	18	1098	18,3
71	6146	102,4	53	3764	62,7	35	2244	37,4	17	1035	17,2
70	5966	99,4	52	3665	61,1	34	2171	36,2	16	0973	16,2
69	6795	96,6	51	3569	59,5	33	2100	35,0	15	0910	15,2
68	5631	93,8	50	3475	57,9	32	2028	33,8	14	0848	14,1
67	5474	91,2	49	3382	56,4	31	1958	32,6	13	0787	13,1
66	5324	88,7	48	3292	54,8	30	1888	31,5	12	0725	12,1
65	5179	86,3	47	3203	53,4	29	1819	30,3	11	0664	11,1
64	5040	84,0	46	3116	51,9	28	1751	29,2	10	0603	10,1
63	4905	81,7	45	3030	50,5	27	1684	28,1	9	0542	9,0
62	4775	79,6	44	2946	49,1	26	1616	26,9	8	0482	8,0
61	4649	77,5	43	2863	47,7	25	1550	25,8	7	0421	7,0
60	4527	75,5	42	2782	46,4	24	1484	24,7	6	0361	6,0
59	4409	73,5	41	2702	45,0	23	1419	23,6	5	0300	5,0
58	4294	71,6	40	2623	43,7	22	1354	22,6	4	0240	4,0
57	4183	69,7	39	2545	42,4	21	1289	21,5	3	0180	3,0
56	4074	67,9	38	2468	41,1	20	1225	20,4	2	0120	2,0
55	3968	66,1	37	2393	39,9	19	1161	19,3	1	0060	1,0

4th. Draw a line AB (ſee Plate VII.) to repreſent a part of the pa- llel of latitude where the chart is to begin (which in this example is e parallel of 23°); and on this line, by the help of a ſcale of equal arts, lay a number of ſucceſſive diviſions to expreſs the propoſed numer of degrees of longitude.

Thus 80 degrees of longitude being propoſed; from ſome ſcale take ne of the primary diviſions, and this diſtance being repeated 8 ſucceſſive mes in the line AB, will give diviſions to every 10th degree of longide; and then let the intermediate degrees be inſerted, whereby AB ill be divided into 80 equal parts of that ſcale; which in this example, the ſcale where 13 ſubdiviſions or degrees make an inch: And in like anner the parts of degrees may be inſerted.

5th. From the ends A, B, draw lines AD, BC, perpendicular to AB; nd on theſe lines lay the diviſions expreſſed by the meridional degrees the foregoing table, beginning at the line AB.

Thus did the chart begin at the equator, and go to 70 degrees of latude; for 70 deg. take 99,4; for 69 deg. take 96,6; for 68 deg. take 3,8, &c.; and theſe diviſions taken from the ſame ſcale, and laid ſe- erally on AD, BC, will give the diviſions for the degrees of latitude in- reaſed in their true proportion; and the like for the intermediate parts f degrees.

But the chart beginning at 23 deg. of lat. the meridional degrees 2 anſwering to 23 deg. of lat. are to be ſubtracted from thoſe belong to all the latitudes introduced in the chart, and the reſpective remain are to be ſucceſſively laid off from A and B towards D and C. Thus

Latit.	59°	58°	57°	56°	55°	54°	53°	52°	51°	&c.
From	73,5	71,6	69,7	67,9	66,1	64,4	62,7	61,1	59,5	&c.
Take	23,6	23,6	23,6	23,6	23,6	23,6	23,6	23,6	23,6	&c.
Leaves	49,9	48,0	46,1	44,3	42,5	40,8	39,1	37,5	35,9	&c.

For the ſeveral meridional degrees of latitude to be taken from the ſa ſcale uſed for the degrees of longitude.

6th. Draw lines thro' the ſeveral correſponding diviſions of latitu and they will repreſent the parallels of latitude: Alſo lines drawn th the diviſions of longitude, will expreſs the meridians or parallels of lo gitude: But in this example, the meridians and parallels are drawn o to every 10 degrees.

7th. From ſome point of the chart as a centre, let the rhumb lines drawn.

726. Note, the difference between the meridional parts to two gi latitudes, is called the meridional difference of latitude; to diſtingu it from the difference of latitude of thoſe two places, reckoned in mi of the equator, and which is called the proper difference of latitude.

In a chart thus conſtructed, every place may, by its latitude and lo gitude, be laid down in its true poſition, with regard to other plac and with as much accuracy as on the globe itſelf; the diſtances of t meridians and parallels of latitude having the ſame proportion to one other in both: Thus on the globe, the diſtance of two meridians in t parallel of 60 degrees is half their diſtance at the equator, becauſe t coſine of 60 degrees is half the radius (319); ſo in the chart, at t latitude of 60 degrees, the meridional difference of latitude to 1 min is double to the meridional difference of latitude of 1 minute from t equator, the ſecant of 60 degrees being double to the radius (329); a the like analogy holds in other correſponding latitudes.

Now as the meridians are parallel right lines, the parallels of latitu cutting the meridians at right angles, and the rhumbs alſo being rig lines; therefore ſuch a chart is of more ſervice to the mariner for m purpoſes, than the globe is.

The properties of the ſeveral lines and angles concerned in ſailing this chart, will be ſhewn in the following propoſitions.

PROPOSITIO

PROPOSITION V.

727. *If a ſhip ſails on any oblique rhumb, the proper difference of titude to the departure, the meridional difference of latitude to the diffe- ce of longitude, and the radius to the tangent of the courſe, are all in the ne ratio.* See Fig. 1. Plate VII.

DEMONSTRATION.

Suppoſe a ſhip from P in the latitude of 30 deg. N. ſhould ſail on rhumb PS, to S in the latitude of 40 degrees north.

Now becauſe ſhe has made 10 deg. of diff. lat.; make PO, in the ridian, equal to 10 degrees of the equator; and draw OR parallel to , meeting the rhumb PS in R.

Then PO expreſſes the proper difference of latitude.
OR the departure.
PR the diſtance ſailed, in equatorial meaſure.
$\angle OPR$ is the angle of the courſe.
And R is the apparent place of the ſhip.

But ſhe having made 10 deg. diff. lat. ſhould be in the parallel of 40 rees; therefore her place, when corrected by longitude, will be in S.

Then QS will be the difference of longitude.
And PQ the meridional difference of latitude.
Now the triangles POR, PQS, are ſimilar.

Therefore $PO : OR :: PQ : QS$. (250)
Alſo $PO : OR :: \text{Rad} : \text{t.} \angle OPR$. (341)

Conſequently. As the proper diff. lat., to the departure;
So the merid. diff. lat., to the diff. longitude.
And So is the Radius , to the tang. of the courſe.

PROPOSITION VI.

28. *The tangents of the angles which different rhumbs make with the ridian, are directly proportional to the differences of longitudes made on the rhumbs to equal meridional differences of latitude: Or, are reciprocally portional to unequal meridional differences of latitudes on thoſe rhumbs, when the differences of longitude are equal.* See Fig. 1. Plate VII.

DEMONSTRATION.

et QS, QV, be the differences of longitudes made on the rhumbs PS PV, to the common merid. diff. lat. PQ; alſo PW, PQ, be the me- rional differences of latitudes, on the ſame rhumbs, to the equal dif- ferences of longitudes WX, QV.

ow $PQ : QV :: R : \tan. \angle QPV$ (341). Therefore $QV \times R = PQ \times$ n. $\angle QPV$. (245)

lſo $PQ : QS :: R : \tan. \angle QPS$.

onſequently $QV : QS :: \tan. \angle QPV : \tan. \angle QPS$. (238)

gain. $PW : (WX =)\ QV :: R : \tan. \angle WPX$.

herefore $QV \times R = PW \times \tan. \angle WPX$. (245)

ut $QV \times R = PQ \times \tan. \angle QPV$, found above.

herefore $PW \times \tan. \angle WPX = PQ \times \tan. \angle QPV$. (137)

onſequently $PQ : PW :: \tan. \angle WPX : \tan. \angle QPV$. (246)

PROPOSI-

PROPOSITION VII.

729. *If a ſhip ſails on ſeveral different rhumbs, the whole meridic diff. lat. is equal to the ſum, or differences of all the ſucceſſive meridic differences of lat.: And the whole diff. long. is alſo equal to the ſum differences of all the ſucceſſive differences of longitudes: Obſerving to t the ſums, when of the ſame name; and the differences when of contr names.* See Fig. 2. Plate VII.

DEMONSTRATION.

1ſt. Suppoſe a ſhip ſails from E in the lat. of 23° N. to G in the rallel of 26 deg. N. Then Eg = mer. diff. lat. and Gg = diff. long

2d. From G to H in the parallel of 28 deg. Then Gh = diff. and hH = diff. long.

Now $Em = Eg + Gh$, is the whole diff. latitude.

And $mH = mh - Hh$, is the whole diff. longitude.

3d. She ſails weſt from H to I: Here ſhe only alters her longit by HI; ſo that her preſent diff. long. is mI.

4th. In ſailing from I to K, ſhe increaſes her diff. long. by kK, f mI to gK; and decreaſes her diff. lat. by Ik, from Em to Eg.

5th. In ſailing north from K to P, the diff. long. pP continues ſame: But the diff. lat. is increaſed by KP, from Eg to Ep.

6th. In running eaſt from P to M, the diff. lat. Ep does not al But the diff. long. is diminiſhed from pP to pM.

7th. By going from M to N; the diff. lat. is increaſed by Ml, f Ep to Eq: And the diff. long. is changed from pM, or ql to qN.

Conſequently, the whole diff. lat. Eq is equal to the ſums, or d rences of all the differences of lat.; and the ſame of qN, the whole ference of longitude.

PROPOSITION VIII.

730. *If the courſe between any two places, outwards and homewards on the oppoſite rhumbs; then in each caſe, the differences of latitude, partures, and differences of longitude, will always be the ſame.* See Fi Plate VII.

DEMONSTRATION.

Suppoſe a ſhip at *a* in lat. 25 deg. N. ſhould ſail on one rhumb t latitude 40 deg. N. ſo as at the end of every third day to alter her lat. 5 deg. or 300 miles; and to return on the oppoſite rhumb in ſame manner.

Thro' the interſections *a* of this rhumb with the parallel of e 5 deg. draw meridians; make *a d*, *af*, each equal to 5 common of the equator; and draw *d b*, *f e*, parallel to the parallels of latitud

Then are the lines *a d*, the proper differences of latitudes outward each third day's account, which muſt be every where equal; and the equal lines *a f*, are the differences of latitudes homewards, to like accounts.

The lines *d b* outwards, and *f e* homewards, are the departures to h third day's account.

The lines *a b* outwards, and *a e* homewards, are the diſtances run to h third day's account.

The meridian lines *a c* outwards, and *a n* homewards, are the me- onal differences of latitude; and the weſt and eaſt lines *c a* outwards l *n a* homewards, taken on the parallels of latitude, are the differ- ces of longitude.

Now it is evident from the conſtruction, that the triangles *a d b*, *a f e*, each account are equal to one another.

Alſo, that the meridional differences of latitude, and the differences longitude, to the accounts between the ſame parallels of latitude wards and homewards, are reſpectively equal to one another.

Conſequently the truth of the propoſition is manifeſt.

PROPOSITION IX.

31. *The diviſions of the meridian line on the Mercator's chart, is a table he differences of longitude anſwering to each minute of latitude on the nb line making an angle of 45 degrees with the meridian.* See Fig. 1. e VII.

DEMONSTRATION.

Let PV be a rhumb of 45 degrees.

Then ſince PQ is at right angles to QV.

Therefore ∠QPV = ∠QVP, each being half a right angle.

Conſequently QV = QP. (194)

Now PQ is the ſum of all the meridional differences of latitude between the parallels thro' P and Q. (723)

And QV is the ſum of all the differences of longitude between the meridians thro' Q and V.

Therefore on a rhumb of 45 degrees, the ſum of all the differences of longitude, is equal to the ſum of all the meridional differences of latitude.

But the ſum of all the meridional differences of latitude, is the ſame as the nautical meridian. (724)

Conſequently. On a rhumb of 45 deg. the difference of longitude, or the ſum of all the intermediate differences of longitude to every minute of latitude, is equal to the correſponding parts of the nautical meridian line.

32. In the Philoſophical Tranſactions, N° 219, Dr. Halley has given a very curious paper relating to the diviſion of the nautical meridian, by a quite different method from Mr. Wright's; and becauſe it contains a method of performing the problems of ſailing according to the true chart, by the help of the common table of logarithmic tangents, without a table of meridional parts; therefore the ſubſtance of that paper is here annexed.

The Doctor ſays: “ It was firſt diſcovered by chance, and, as “ as I can learn, firſt publiſhed by Mr. *Henry Bond*, as an addition “ Norwood's epitomy of Navigation, about the year 1645, that “ *meridian line was analogous to a ſcale of logarithmic tangents of half* “ *complements of the latitude.* The difficulty to prove the truth of t “ propoſition, ſeemed ſuch to Mr. Mercator,” (an ingenious mathem tician then living, and) “ the author of the Logarithmotechnia, th “ he propoſed to wager a good ſum of money, againſt whoſo wou “ fairly undertake it, that he ſhould not demonſtrate either, that it w “ true or falſe: And about that time Mr. John Collins holding a co “ reſpondence with moſt of the eminent mathematicians of the age, “ excite them to this enquiry.

“ The firſt that demonſtrated the ſaid analogy, was the excellent M “ James Gregory in his Exercitationes Geometricæ, publiſhed an “ 1668, which he did, not without a long train of conſequences a “ complication of proportions, whereby the evidence of the demonſtr “ tion is in a great meaſure loſt, and the reader wearied before attains it:” The Doctor proceeds and ſays, “ nor hath any one, th “ I know of, yet diſcovered the rule for computing independently t “ interval of the meridional parts anſwering to any two given latitudes

The Doctor then in a very elegant manner gives the demonſtrati of the ſaid analogy; and draws ſeveral uſeful concluſions: But as hi ſelf confeſſes, he is too conciſe for learners; and the writers on t ſubject have been rather more, or at leaſt as conciſe as the Docto therefore in order to ſet this affair in a clear light, and keeping to t Doctor's principles, it was thought convenient to diſpoſe of the ſubj in the following manner: But the ſaid propoſition may be proved fr very different principles than thoſe uſed by the Doctor.

PROPOSITION X.

733. *On the Globe, the rhumb lines oblique to the meridians are ſpira which continually approach the poles but never meet them.*

DEMONSTRATION.

In any place on the ſurface of the globe, the rhumb running no and ſouth, coincides with the meridian of that place; the eaſt and w rhumbs are perpendicular to the meridian, and the other rhumbs oblique to it: But this obliquity is the ſame under every meridia therefore all the rhumbs, except the north and ſouth, cut the meridi at equal angles.

When right lines are parallel to each other, a right line will cut th at equal angles (185): But not ſo when the lines are inclined to o another; therefore ſeveral inclining lines cannot be cut at equal ang but by a curve line bending towards the place where thoſe lines wo meet.

Now the meridians on the globe meeting in the poles, are incli to one another; therefore the oblique rhumbs cutting them at eq angles, are curve lines continually approaching the poles.

I

But in every latitude, an oblique rhumb runs between the preſent rallel and the pole.

And a line cannot cut ſeveral other lines at equal angles in one int.

Conſequently the rhumb lines are ſpirals, which continually wind und the poles without ever falling into them.

PROPOSITION XI.

734. *The ſpiral rhumbs on the globe are of the ſame kind with the portional ſpiral.* See Fig. 3. Plate VIII.

DEMONSTRATION.

Let CAEB repreſent part of the ſtereographic projection of the ſphere the plane of the equator; where AEB is part of the equator, C the le, CA, CD, CE, &c. are meridians; and the ſpiral A *d e f* one of rhumbs.

Now in every ſtereographic projection, the lines therein, interſecting h other, form angles equal to the angles on the ſphere which they reſent. (432)

Therefore the projection of the rhumb line A *d e f*, cuts the radii or ridians AD, AE, &c. at equal angles.

But this is a property alſo of the proportional ſpiral. (291)

Therefore the ſpiral rhumbs are analogous to the proportional ſpiral.

735. COR. Hence the differences of longitude AD, AE, AF, &c. are logarithms of the intercepted parts C *d*, C *e*, C *f*, &c. of the me-ians. (292)

PROPOSITION XII.

736. *The logarithmic tangents of the half complements of the latitudes, are alogous to the lengthened degrees in the nautical meridian line.*

DEMONSTRATION. See Fig. 3. Plate VIII.

Let the figure CADEB be part of the ſtereographic projection of the ſere on the plane of the equator as in the laſt propoſition: And on ay rhumb, let the points A, *d*, *e*, *f*, &c. repreſent certain places on globe, whereof A is a point in the equator; then will D *d*, E *e*, F *f*, . expreſs their latitudes; and the arcs AD, AE, AF, &c. their differces of longitude from A; alſo C being the pole, the lines C *d*, C *e*, *f*, &c. are the complements of latitude.

Now in this projection, the lines C *d*, C *e*, C *f*, &c. are equal to the tgents of half the co-latitudes. (428)

And the differences of longitude AD, AE, AF, &c. are the logarithms thoſe tangents, or of the lines C *d*, C *e*, C *f*, &c. (292)

Therefore the differences of longitude are as the logarithmic tangents the half co-latitudes.

But the lengthened degrees on the nautical meridian, are as the differces of longitude on the rhumb of 45 deg. (731)

Conſequently, the log. tangents of the half co-latitudes, are as tl lengthened degrees on the nautical meridian.

737. Cor. I. When the angle between the rhumb line and the me ridian is equal to 45 deg.; then the longitudes of places on that rhumb a expreſſed by logarithms of Nepier's kind (295); whoſe correſpondir numbers are natural tangents of the half co-latitudes (not to degrees ar minutes, but) to arcs expreſſed in parts of the radius.

738. Cor. II. Hence to any two places on a rhumb of 45 deg. tl difference of longitude, or the meridional difference of latitude (731 is equal to the difference of the Neperian logarithm tangents of the ha co-latitudes of thoſe places, eſtimated in parts of the radius.

739. Cor. III. As there may be an indefinite variety of rhumbs, ar therefore as many different kinds of logarithms (294); conſequently eve ſpecies of logarithms has its peculiar rhumb, diſtinguiſhable by the ang it makes with the meridian: And among theſe muſt be two, whereto tl differences of longitudes are the differences of the logarithm tangents the half co-latitudes, eſtimated in minutes of a degree, one of whic belongs to Nepier's form of logarithmic tangents, and the other t Briggs's, or the common logarithmic tangents.

740. Cor. IV. Hence in every point of theſe rhumbs, the differen of the logarithms anſwering to the radii of thoſe points (or of the log rithmic tangents of the half co-latitudes of thoſe points) are the true di ferences of longitude made by a ſhip in ſailing on that rhumb thro' tl latitudes of thoſe ſucceſſive points.

PROPOSITION XIII.

741. *The common logarithmic tangents, are the ſame as a table of t differences of longitude to every minute of latitude, on the rhumb line makin an angle with the meridian of* 51° 38′ 09″.

Demonstration.

Suppoſe z to repreſent the meridional difference of latitude betwee two places on the rhumb of 45 degrees; or (736) the difference betwe the logarithmic tangents of the half co-latitudes of thoſe places; eſt mated either in parts of the radius, or in minutes.

Then, As the circumf. in parts of the radius 62831,853, (27
To the circumf. in min. of a degree 21600;
So is a mer. diff. lat. in parts of the radius z,
To a mer. diff. lat. in min. of a degree 0,34377468 × z

whoſe correſponding rhumb is different from that which z belong to; and the angle which this rhumb makes with the meridian will found by art. 728.

For, As the mer. diff. lat. in min. on one rhumb 0,34377468 ×
To a merid. diff. lat. in min. on a rhumb of 45°, z;
So is the natural tangent of the rhumb of 45° 10000,
To the natural tangent of the other rhumb 29088,821,

which anſwers to 71° 01′ 42″; and under this angle is the meridi interſected by that rhumb line, on which the differences of Nepier's l garithm rithmic tangents of the half co-latitudes, are the true differences of ngitude eſtimated in minutes and parts.

But Nepier's logarithms are to Briggs's as 2,30258, &c. to 1 *.

Therefore 2,30258, &c. : 1 : : 29088,821 : 12633,114, &c. which the tangent of 51° 38′ 09″, wherein the meridian is cut by the rhumb, which the differences of Briggs's, or the common log. tangents of the lf co-latitudes, are the true differences of longitude correſponding to oſe latitudes.

PROPOSITION XIV.

742. *The difference of the common logarithmic tangents of the half co-la-udes of any two places, to the meridional difference of latitude in minutes, in the conſtant ratio of* 1263,3 *to* 1 †.

DEMONSTRATION.

The com. log. tangents are as the differences of longitude on the rhumb) of 51° 38′ 09″, whoſe natural tangent is 12633114. (741)

The nautical meridian is a ſcale of longitudes on the rhumb (B) of 45° 31), whoſe tangent being equal to the radius, may be expreſſed by ity.

And the differences of longitude to equal differences of latitude on ferent rhumbs, being to each other, as the tangents of the angles thoſe umbs make with the meridian. (728)

Therefore, As the tangent of A (51° 38′ 09″) = 1263,3,
To the tangent of B (45°) = 1000;
So is the diff. longitude on A, or the diff. log. tan. of the half co-latitudes of two places,
To the diff. longitude on B, or the meridional diff. latitudes of thoſe places.

In this manner may a table of meridional parts be readily conſtructed ew, or the former ones be examined, if it was thought neceſſary: t the tables in common uſe having gone through many careful hands, ey may be received as ſufficiently correct.

From the preceding propoſitions may all the problems relating to the ie method of ſailing be accurately reſolved; and altho' they are here contained under the general title of Globular ſailing, yet as the com-on cuſtom has been to diſtinguiſh different kinds, wherein the longi-de is conſidered; ſo here, in compliance with ſuch cuſtom, it was ought proper to retain the uſual forms, *viz.* *Parallel ſailing*, *Middle itude ſailing* and *Mercator's ſailing*, or more properly *Wright's ſailing*; ich are diſtinctly treated of in what follows.

---

[*] Nepier's log. of 10 is 2,30258 &c. (78)
And Briggs's, or the common log. of 10, is 1. (75)

[†] When the tables of logarithms have 7 decimal places, then 1263,3 to 1 y be uſed for the conſtant ratio: But if they conſiſt of fewer places, as of 6, n $\frac{1}{10}$th of this number 1263,3 is to be uſed; if of 5 places then take $\frac{1}{100}$th . ; which is readily done by removing the comma as many places to the left d as the tables conſiſt of places leſs than ſeven.

SECTION

SECTION III.

Of Parallel ſailing.

743. Parallel sailing *is the art of finding what diſtance a ſhip ſho run due eaſt or weſt, in ſailing from the meridian of one place to that another given place, in any parallel of latitude.*

This kind of piloting is generally uſed in conducting a ſhip to iſland detached from the main land, or other iſlands; and alſo on ot occaſions.

The method of performing which, is by ſailing to the parallel of titude the place is in, keeping a good account, ſo as to be certain wh ther the place is then to the eaſtward, or weſtward; and alſo, if poſſib to know the longitude arrived at; and then to run due weſt, or ea until the ſhip comes near the longitude of the given place; where is then ſure to make the port required.

The computations in parallel ſailing depend on the following

Rule.

744. *As Radius,*
To the coſine of the latitude of any parallel;
So is the miles of longitude between any two meridians,
To the diſtance of thoſe meridians in that parallel.

For the demonſtration ſee art. 719.

From the ſame propoſition is eaſily deduced the following

Rule.

745. *As the coſine of one latitude,*
Is to the coſine of another latitude;
So is a given meridional diſtance in the firſt parallel,
To a correſponding meridional diſtance in the ſecond parallel.

746. And hence ariſe the following proportions,

R : S :: L : D.
S : R :: D : L.
L : D :: R : S.
S : *s* :: D : *d*.
D : *d* :: S : *s*.

Whereby all the caſes that can happen in this kind of ſailing are re dily reſolved by the logarithms, and alſo by the following Table, c culated for a difference of longitude of 1 degree, or 60 nautical mil of the equator, by the firſt rule. Thus.

As Radius, to the coſine of any latitude; ſuppoſe 30°,
So 60 *miles of longitude, to the meridional diſtance* 51,96.

And the like to the other latitudes.

A Tab

47. *A* TABLE *ſhewing how many miles anſwer to a degree of longitude, at every degree of latitude.*

Lat.	Miles	Lat.	Miles	Lat.	Miles	Lat.	Miles	Lat.	Miles	Lat.	Miles
1	59,99	16	57,67	31	51,43	46	41,68	61	29,09	76	14,51
2	59,96	17	57,38	32	50,88	47	40,92	62	28,17	77	13,50
3	59,92	18	57,06	33	50,32	48	40,15	63	27,24	78	12,48
4	59,85	19	56,73	34	49,74	49	39,36	64	26,30	79	11,45
5	59,77	20	56,38	35	49,15	50	38.57	65	25,36	80	10,42
6	59,67	21	56,01	36	48.54	51	37,76	66	24,41	81	9,38
7	59,56	22	55,63	37	47,92	52	36,94	67	23,44	82	8,35
8	59,42	23	55,23	38	47,28	53	36,11	68	22,48	83	7,32
9	59,26	24	54,81	39	46,63	54	35,27	69	21,50	84	6,28
10	59,09	25	54,38	40	45,96	55	34,41	70	20,52	85	5,23
11	58,89	26	53,93	41	45,28	56	33,55	71	19,53	86	4,18
12	58,69	27	53,46	42	44,59	57	32,68	72	18,54	87	3,14
13	58,46	28	52,97	43	43,88	58	31,79	73	17,54	88	2,09
14	58,22	29	52,47	44	43,16	59	30,90	74	16,54	89	1,05
15	57,95	30	51,96	45	42,43	60	30,00	75	15,53	90	0,00

The uſe of this table will be evident from what follows.

748. *If the meridional diſtance is wanted to degrees and minutes, proceed us.*

Take the difference of the meridional diſtances to the given degrees, d thoſe which are next greater; multiply this difference by the given nutes, and divide the product by 60; then the quotient ſubtracted m the miles againſt the given degrees in the table, will leave the meridional diſtance required.

749. *But if a meridional diſtance, intermediate to thoſe in the table, as given to find the correſponding degrees and minutes.*

Subtract the given meridional diſtance from the next greater, found in t table; multiply the remainder by 60; divide the product by the difference of the meridional diſtances next greater and leſs than the given e; then the quotient annexed as minutes to the degrees of the next eater meridional diſtance, will give the degrees and minutes ſought.

EXAM. to firſt rule.

How many miles anſwer to a degree long. in the lat. of 48° 26′?

Lat. 48°	40,15 miles.
Lat. 49°	39,36 miles.

The diff. is 0,79, which multip. 26, gives 20,55; this divided by gives 0,38; which taken from 40,15 ves 39,77, the miles required.

EXAM. to ſecond rule.

In what lat. does 46,08 *miles anſwer to one deg. of longitude?*

From	46,63, the miles to 39°.
Take	46,08, the given miles.

Leaves 0,55; which multip. by 60, gives 33,00; this divided by 0,67, the diff. between 39° and 40°′ gives 49′: So 39° 49′ is the lat. ſought.

750. Case I. Given the latitude and difference of longitude: I quired the diſtance.

Exam. *A ſhip in the latitude of 32° N. ſails thence due eaſt till difference of longitude is 384 miles: Required the diſtance ſhe has run?*

By Construction *. Fig. 4. Plate VIII.

From any point P, with the radius of 90°, taken from the ſcale natural ſines, deſcribe the arc EQ; draw the chord EQ equal to 3 miles; and draw the radii PE, PQ.

From the ſame point P, with a radius equal to the ſine of 58° (comp. lat.), taken from the nat. ſines, deſcribe the arc AB; and dr the chord AB, whoſe meaſure is the diſtance ſought.

Here P repreſents the north pole; the arc EQ the equator; the AB a parallel of latitude; the chord EQ is the difference of longitu the chord AB is the meridional diſtance ſought; A is the place fai from, B the place arrived at; and the radii PE, PQ, expreſs the m- dians of the place ſo ſailed from, and come to.

By Computation.

As Radius	=	90° 00′	10,00000
To coſ. lat.	=	32 00	9,92842
So miles long.	=	384	2,58433
To miles diſt.	=	325,6	2,51275

So that ſhe has run 325,6 miles.

By the Table.

Seek the miles to the given latitude; multiply them by the given d longitude; the quotient divided by 60 will give the meridional diſta ſought.

Thus. To lat. 32° anſwers 50,88 miles.
Multiply by 384 the given diff. longitude.

20352
40704
15264

60)19537,92(325,632 = merid. diſt. ſought.

---

* This and the conſtruction of the following caſes depend on the Ortho phic projection † of the circles of the ſphere on the plane of the equator, circle being the primitive, and its centre or pole repreſenting the point which the pole of the earth is projected; conſequently the diſtance from pole, of any parallel of latitude, muſt be expreſſed by the complement of latitude.

† This projection is formed by ſuppoſing that any point on the ſurface of a ſphere is proj on a plane paſſing thro' its centre, by a line drawn thro' that point perpendicular to the pl which amounts to the ſame, as if the viſual ray came from an eye at an infinite diſtance. Thus in Fig. 1. Pl. VIII. perpend. lines thro' B, *b*, project thoſe points in *t*, *z*, on the plane *Fa* Therefore ſmall circles on that plane are deſcribed with the radii E *t*, E *z*, = the ſines of the PB, P *b*.

751. CASE II. Given the latitude and meridional diſtance: Re- ired the difference of longitude.

EXAM. *A ſhip from the latitude 53° 36′ N. longitude 10° 18′ E. ſails e weſt 236 miles: Required her preſent longitude?*

By CONSTRUCTION. Fig. 4. Pl. VIII.

From the point P, with the ſine of 90°, and the coſine of 53° 36′, ſcribe the arcs EQ, CD. Draw the chord CD = 326; thro' C and D aw the radii PE, PQ; then the chord EQ being drawn, will be the ference of longitude.

By COMPUTATION.				
As PC, the coſ. lat.	= 53° 36′	0,22664	6,0)39,8(6° 38′.	
To PE, Radius	= 90 00	10,00000	Long. from	10 18 E.
So CD, merid. diſt.	= 236 m.	2,37291	Diff. long.	6 38 W.
To EQ, diff. long.	= 397,7	2,59955	Long. in	3 40 E.

BY THE TABLE.

Find the meridional diſtance to a deg. of long. in lat. 53° 36′ (748), l make it a diviſor to the product of the given meridional diſtance by ; then will the quotient be the diff. long. ſought.

Thus. The diff. merid. diſt. to 53° and 54°, is 0,85; which multi- ed by 36′ and divided by 60′, gives 0,51; this taken from 36,11, t merid. diſt. to 53°, leaves 35,6 for the merid. diſt. to 53° 36′: Then 6 multiplied by 60, and the quotient divided by 35,6, gives 397,7 the diff. long. ſought.

752. CASE III. Given the difference of longitude, and its corre- nding meridional diſtance: Required the parallel of latitude.

EXAM. *In what latitude does 384 miles of meridional diſtance anſwer to 0 miles of diff. longitude?*

BY CONSTRUCTION. Fig. 5. Pl. VIII.

From the point P, with the ſine of 90°, deſcribe the arc EQ; draw t chord EQ = 500, and draw the radii PE, PQ; make EC = 384, w CB parallel to EP; then the arc AB being deſcribed with the radius , is the parallel of lat. ſought.

BY COMPUTATION.			
As EQ, the diff. long.	= 500	7,30103	So in the lat. 39° 49′
To AB, merid. diſt.	= 384	2,58433	384 miles of merid. diſt.
So PE, Radius	= 90° 00′	10,00000	anſwers to 500 miles of
To PA, the coſ. lat.	= 39 49	9,88536	longitude.

BY THE TABLE.

The given merid. diſt. 384 being multiplied by 60, and the product ided by the given diff. long. 500, gives 46,08, the merid. diſt. to deg. of long. in the lat. ſought: And by article 749, the latitude will found to be 39° 49′.

753. Case IV. Given the diſtance of two places in a given parall of latitude: Required the diſtance of two other places, under the ſam meridians with the former, in another given parallel of latitude.

Exam. *From two ports in the lat.* 32° 20′ *N. diſtant* 256 *miles, tw ſhips ſail directly north: How far are they diſtant from one another, wh they come to the lat.* 44° 30′ *N.*

By Construction. Fig. 6. Pl. VIII.

From the point P, with radii equal to the coſines of 32° 20′, ar 44° 30′, deſcribe the arcs AB, DE; draw the chord AB = 256, ar draw PA, PB; then will the chord DE be the diſt. ſought.

By Computation.

As PA, the coſ. of lat. from	=	32° 20′	0,07317
To PD, the coſ. of lat. in	=	44 30	9,85324
So AB, the firſt diſt.	=	256	2,40824
To DE, the preſent diſt.	=	216,1	2,33465

By the Table.

The merid. diſtances to 32° 20′, and 44° 30′, (found by 748) a 50,7 and 42,8: Then the given merid. diſtance 256 multiplied by 42, and the product 1095,68 divided by 50,7; the quotient 216,1 is t meridian diſtance ſought.

754. Case V. Given the diſtances between the ſame two meridia in different parallels, and alſo the latitude of one parallel, to find t latitude of the other.

Exam. *If two ſhips in the lat.* 44° 30′ *N., diſtant from one anoth* 216 *miles, ſhould both ſail thence directly ſouth until their diſtance is* 25 *miles: What latitude are they come to?*

By Construction. Fig. 7. Pl. VIII.

From P, with a radius of the coſine of 44° 30′, the lat. ſailed fro deſcribe the arc DE; draw the chord DE = 216; and thro' D and draw PA, PB; continue DE till DF = 256; thro' F draw FB parallel PA, meeting PB in B; then an arc deſcribed from P, thro' B and will be the parallel of latitude come to.

By Computation.

As DE, the firſt diſt.	=	216	7,66554
To AB, the ſecond diſt.	=	256	2,40824
So PD, the coſ. lat. from	=	44° 30′	9,85324
To PA, the coſ. lat. in	=	32 17	9,92702

By the Table.

To lat. 44° 30′, find (748) the mer. diſt. 42,8; this multiplied by 25 and the product divided by 216, gives 50,72; which (by 749) will found to be the merid. diſt. to 32° 17′, the latitude ſought.

55. *Other Examples to exerciſe the foregoing caſes.*

Ex. I. *What is the diſtance between St. Maries in lat.* 37° 00′ *N. long.* ° 56′ *W., and Cape Henry in lat.* 37° 00′ *N. long.* 76° 23′ *W.?*

As Rad : coſ. lat. 37° 00′ : : diff. long. 3207 : diſtance 2561.

Ex. II. *A ſhip from Cape Clear ſails weſt* 265 *miles: What long. is ſhe* *ne to?*

As coſ. lat. 51° 18′ : Radius : : merid. diſt. 265 : diff. long. 423,8.
Anſwer. The preſent longitude is 16° 54′ W.

Ex. III. *A ſhip having run due eaſt for* 3 *days, at the rate of* 5 *knots an* *r, finds ſhe has altered her longitude* 8° 16′ *: What parallel of latitude* *ſhe ſail in?*

As diff. long. 496 : merid. diſt. 360 : : Rad : coſ. lat. 43° 28′.

Ex. IV. *Suppoſe two ſhips in the parallel of* 47° 54′ *N., their difference* *long. being* 9° 35′, *ſhould both ſail thence directly ſouth* 836 *miles: How* *were they diſtant, at the beginning, and end of their courſes?*

As Rad : coſ. lat. 47° 54′ : : diff. long. 575 : firſt merid. diſt. 385,5 m.
Now 836 miles = 13° 56′; therefore the lat. come to is 33° 58′.
As Rad : coſ. lat. 33° 58′ : : diff. long. 575 : laſt merid. diſt. 476,9 m.

Ex. V. *What is the diff. lat. between two parallels on different ſides of the* *ator, when, between the ſame two meridians, the meridional diſtance in* *northern parallel is* AB = 238 *miles, in the ſouthern parallel is* CD = 5 *miles, and at the equator is* EQ = 352 *miles?*

As diff. long. 352 : north. mer. diſt. 238 : : Rad : coſ. lat. 47° 27′ N.
As diff. long. 352 : ſouth. mer. diſt. 195 : : Rad : coſ. lat. 56° 22′ S.
Then the ſum of theſe two latitudes, *viz.* 103° 49′, is the diff. lat. ſought.

In this figure 8, Pl. VIII, P is the north pole, and S is the ſouth e; but the conſtruction on one ſide of the equator is ſufficient, as is dent by drawing E *d* parallel to PE, and *d c* parallel to EQ.

The difference of longitude and meridional diſtances may be conſider- e as tangents to their reſpective arcs, as well as chords. (259)

Among the natural ſcales on the Gunter, are two, which uſed tly anſwer the end of the foregoing table; theſe are a ſcale of chords rked *CH*, and a ſcale of longitude marked *ML*, ſtanding cloſe to one ther; and are thus uſed.

Find the given latitude on the ſcale of chords, and right againſt it, the ſcale of longitude, is the diviſion expreſſing the miles of merid. ance in that lat. to one degree of longitude.

Thus againſt the chord 60°, ſtands 30 miles; and the chord 50°, nds between 38 and 39 miles: And ſo of the reſt.

SECTION

SECTION IV.

Of Middle latitude, and Mercator's ſailings.

Of Middle latitude ſailing.

756. Middle latitude sailing, *is a manner of ſolving the ſeveral caſes of globular ſailing, by the principles of plane and parallel ſaili jointly.*

This method, which is not quite accurate, is founded on the follo ing ſuppoſition.

757. *The departure is reckoned as a meridional diſtance in that latitu which is a middle parallel between the latitude ſailed from, and the latitu come to.*

Now altho' the arithmetical mean of the coſines of two diſtant la tudes is not the coſine of the arithmetical mean of thoſe latitudes; n ther is the departure between two places on an oblique rhumb equal the diſtance between their meridians in a mean latitude; yet when t parallels of thoſe places are near the equator, or not far diſtant from o another in any latitude, the error becomes ſo ſmall, as not to affect t nautical concluſions drawn from the foregoing ſuppoſition.

This artifice ſeems to have been invented on account of the eaſy ma ner in which the ſeveral caſes may be reſolved by the Traverſe Tabl And where a table of meridional parts is wanting. The computatic depend on the following rules.

Rule I.

758. Add the latitude ſailed from to the latitude arrived at, and ta half the ſum for the middle latitude.

Rule II.

759. As the coſine of the middle latitude, =
Is to the Radius; =
So is the departure, =
To the difference of longitude. =

Rule III.

760. As the coſine of the middle latitude, =
Is to the tangent of the courſe; =
So is the difference of latitude, =
To the difference of longitude. =

The ſecond rule is the ſame as the firſt rule in parallel ſailing, wh is demonſtrated at art. 719.

Demonſtrat

Demonſtration of the third rule.

Now coſ. mid. lat. : Rad : : departure : diff. long. (719)
Therefore Rad × dep. = coſ. mid. lat. × diff. long. (245)
Alſo diff. lat. : depart. : : Rad : tang. courſe. (684)
Therefore Rad × dep. = diff. lat. × tang. courſe. (245)
Conſequently coſ. mid. lat. × diff. long. = diff. lat. × t. courſe. (137)
Therefore coſ. mid. lat. : tan. courſe : : diff. lat. : diff. long. (246)

From rules II and III ariſe the following proportions.

C : R : : D : L.
L : D : : R : C.
R : C : : L : D.

C : T : : P : L.
P : L : : C : T.

Where the letters ſignify the names they ſtand againſt in the rules.

Of Mercator's ſailing.

761. MERCATOR'S SAILING *is the art of reſolving the ſeveral caſes of lobular ſailing by Plane Trigonometry and a table of meridional parts, or arithmic tangents.*

The computations herein are performed by the following rules.

762. Rule I.		Therefore
As merid. diff. lat.	= M.	M : L : : R : T.
To diff. longitude;	= L.	R : T : : M : L.
So is the Radius,	= R.	T : R : : L : M.
To tang. courſe.	= T.	

763. Rule II.		Therefore
As the prop. diff. lat.	= P.	
To the departure;	= D.	P : D : : M : L.
So mer. diff. lat.	= M.	M : L : : P : D.
To diff. longitude.	= L.	

Theſe rules are demonſtrated at Prop. IV. (727)

764. Rule III.		Therefore
As diff. log. tan. ½ co-lats.	= G.	G : N : : L : T.
To tang. of 51° 38′ 09″;	= N.*	N : G : : T : L.
So is a given diff. long.	= L.	T : L : : N : G.
To tang. courſe.	= T.	

For the demonſtration of this analogy, ſee Prop. XIII. (742)

---

* The log. tangent of 51° 38′ 09″ is 10,10151.

PROBLEM I.

765. *Given the latitudes of two places.*
Required the meridional difference of lat. between thoſe places.

Case I. When both places are on one ſide of the equator.

Rule I. The difference of the meridional parts anſwering to latitude, will give the meridional difference of latitude required.

Rule II. The difference of the log. tangents of the half co-latit divided by 12,63, will give the meridional difference of latitude requi

Exam. I. *What is the meridional difference of latitude between the i of St. Thomas and Gibralter?*

By the meridional parts.
Gibralter lat. 36° 13′ N.
St. Thomas's lat. 00 00
Merid. parts to 36 13 2334
Merid. parts to 00 00 0000
Merid. diff. lat. = 2334

By the log. tangents.
Co-lat. = 53° 47′; ½ co-lat. = 26
Co-lat. = 90 00; ½ co-lat. = 45
Log. tang. 10,00000 to 45
Log. tang. 9,70498 to 26
12,63) 29502 (2335
4242
4530
7410

Exam. II. *What is the meridian difference of latitude between the Liz and Cape Verd?*

By the meridional parts.
C. Verd's lat. 14° 43′ N.
Lizard's lat. 49 57 N.
Merid. parts to 49 57 3470
Merid. parts to 14 43 893
Merid. diff. lat. = 2577

By the log. tangents.
Co-lat. = 75° 17′; ½ co lat. = 37
Co-lat. = 40 03; ½ co lat. = 20
Log. tang. 9,88707 to 37
Log. tang. 9,56146 to 20
12,63) 32561 (2578 = n

766. Case II. When the given places are on different ſides of equator.

Rule I. The ſum of the meridional parts anſwering to each latit will be the meridional difference of latitude required.

Rule II. The ſum of the log. co-tangents, abating the index, the half co-latitudes, divided by 12,63, will be the meridional differe of latitude required.

Exam. *What is the meridional difference of latitude between the Verd, and the iſland of St. Helena?*

By the meridional parts.
C. Verd's lat. 14° 43′ N.
St. Helena's lat. 16 00 S.
Merid. parts to 16 00 973
Merid. parts to 14 43 893
Merid. diff. lat. = 1866

By the log. tangents.
Co-lat. = 75° 17′; ½ co-lat. = 37
Co-lat. = 74 00; ½ co-lat. = 37
Log. cot. 0,11293 to 37
Log. cot. 0,12288 to 37
12,63) 23581 (1867 = n

PROBL

PROBLEM II.

767. *Given the lat. of one place, and the merid. diff. lat. between that and another place.*
Required the latitude of the other place.

Case I. When the given lat. and mer. diff. lat. have like names.

Rule I. To the merid. parts of the given lat. add the given meridio- l diff. lat.; ſeek the ſum in the tab. of merid. parts, and the corre- ponding deg. and min. gives the lat. ſought.

Rule II. Multiply the given merid. diff. lat. by 1263; ſubtract the oduct, rejecting all to the right of the 5th decimal place *, from the g. tang. of the given half co-lat.; ſeek the degrees to the remainder long the log. tang. theſe deg. doubled, gives the co-lat. required.

Exam. *A ſhip from the lat. 14° 43′ N. ſails northward till ſhe finds her rid. diff. lat. is 2578: What lat. is ſhe come to?*

By meridional parts.

To the lat. 14° 43′ N.
The mer. parts = 893 N.
Add mer. diff. lat. = 2578 N.
The ſum is = 3471
which anſwers to 49° 57′ N.
The latitude ſought.

By log. tangents.

The co-lat. is 75°17′; ½ co-lat. 37°38′.
And 2578 multiplied by 1263, gives 32560,14.
From 9,88707 = log. tan. 37° 38′.
Take 0,32560
Leaves 9,56147 = log. tan. 20° 01′.
which doubled is 40° 02′.
Whoſe comp. is 49° 58′ = lat. ſought.

768. **Case II.** When the given lat. and mer. diff. lat. have unlike nes.

Rule I. Take the difference between the merid. parts of the given lat. d the merid. diff. lat. the remainder found in the table of merid. parts, ill give the latitude ſought.

Rule II. Multiply the given mer. diff. lat. by 1263; add the product t the log. tang. of the given half co-lat. the deg. to the tang. of the ſum ing doubled, gives the co-latitude required.

Exam. *A ſhip from the lat. 49° 57′ N. ſails ſouthward till her merid. diff. lat. is 2578: What latitude is ſhe come to?*

By meridional parts.

To the lat. 49° 57′ N.
The merid. parts = 3470 N.
ubt. merid. diff. lat. = 2578 S.
emains merid. parts 892
which anſwers to 14° 43′ N.
The latitude come to.

By log. tangents.

Co-lat. 40° 03′; ½ co-lat. 20° 01′.
And 2578 × 1263 = 32560,14.
To 9,56146 = log. tang. 20° 01′.
Add 0,32560
Sum 9,88706 = log. tang. 37 38
which doubled is 75° 16′.
Whoſe comp. is 14 44 = lat.

---

* That is, rejecting all below the number of places in the tables uſed.

PROBLEM III.

769. Given the latitudes and longitudes of two places. Required their bearing and diſtance.

EXAM. *What is the courſe and diſtance from Cape Clear, in Irela to the iſland of St. Mary, one of the Azores?*

BY MIDDLE LATITUDE SAILING.

C. Clear's lat.	51° 18′ N.		Long.	9° 50′ W.	
St. Mary's lat.	37 00 N.		Long.	22 56 W.	
Diff. lat.	14 18	= 858 m.	Diff. long.	13 06	= 786 m.
Sum latitudes	88 18				
Mid. lat.	44 09				
Co. Mid. lat.	45 51				

BY CONSTRUCTION. Fig. 9. Plate VIII.

Draw the meridian AD; deſcribe the quadrant A mp with the ſine 90°, and the arc EF with the coſine of the middle latitude. Make chord mB equal to 786, the diff. longitude; draw AB cutting the EF in F, and draw the chord EF. Make AD equal to 858, the diff. draw DC parallel to A p and equal to EF; and draw AC.

Then AC is the diſtance, and the angle DAC is the courſe.

BY COMPUTATION.

For the Courſe.				*For the Diſtance.*			
P : L :: C : T.			(760)	ſin. ∠C : AD :: R : AC.			
As diff. lat.	=	858	7,06651	As coſ. Cou.	=	33° 19′	0,077
To diff. lon.	=	786	2,89542	To diff. lat.	=	858	2,93
So coſ. m. lat.	=	45° 51′	9,85583	So Rad	=	90° 00′	10,00
To tan. cour.	=	33 19	9,81776	To diſt.	=	1027	3,011

BY THE TRAVERSE TABLE.

1ſt. With the co-mid. lat. found among the degrees, and the d longitude, or ſome part thereof, (if too large) taken among the diſtanc find the departure, or ſome part thereof, in its column.

Obſerving to multiply this Depart. by the ſame number the diff. l gitude was divided by.

2d. With the diff. lat. and dep. together, or their like parts, find courſe among the degrees, and the diſtance in its column.

Let the diff. long. 786 be broke into parts; *viz.* into 100 taken ſe times, and into 86: And as the co-mid. lat. is 45° 51′, or $45\frac{5}{6}$°; proce thus.

The departures to 100, in the columns of 45° and 46°, are 70,7 a 71,9; the diff. is 1,2; $\frac{5}{6}$ parts thereof is 1,0.; which added to 70,7 mak 71,7 for the dep. to 100; and for 700 it will be 501,9: Alſo, the dep tures to 86 in the columns of 45° and 46°, are 60,8 and 61,9; $\frac{5}{6}$ of th diff. is 0,9, and this with 60,8 makes 61,7, the dep. to 86; and the wh dep. = 563,6.

N

Now take $\frac{1}{20}$ of the diff. lat. 858, and of the dep. 564, *viz.* 42,9 d 28,2; theſe will be found together under 33° 15′ for the courſe; and tween 51 and 52 diſt.; ſuppoſe 51½; which taken 20 times gives 1030 r the diſtance.

70. BY MERCATOR'S SAILING.

C. Clear long.	9° 50′ W.	Lat.	51° 18′	Mer. parts	3597
St. Mary's long.	22 56	Lat.	37 00	Mer. parts	2393
Diff. long.	13 06	Diff. lat.	14 18	Mer. diff. lat.	1204
Or 786 miles.		Or 858 miles.			

BY CONSTRUCTION. Fig. 17. Plate VIII.

Draw the meridian AB, and deſcribe the quadrant A m p; make AD : 858, the proper diff. lat. and AB = 1204, the merid. diff. lat.; aw DC, BE, parallel to A p; make BE equal to 786, the diff. long. and aw AE.

Then A is the place of Cape Clear, C that of St. Mary's; AC is the ſtance, CD the departure, and the angle DAC is the courſe.

COMPUTATION *by Meridional parts.*

For the Courſe.

M : L :: R : T. (762)			
mer. d. lat.	=	1204	6,91937
diff. long.	=	786	2,89542
Rad	=	45° 00′	10,00000
tan. Cour.	=	33 08	9,81479

For the Diſtance.

ſin. ∠C : AD :: R : AC.			
As coſ. Cour.	=	33° 08′	0,07707
To prop.d.lat.	=	858	2,93349
So Rad	=	90° 00′	10,00000
To Diſt.	=	1024	3,01056

COMPUTATION *by Logarithmic tangents.*

C. Clear's lat.	51° 18′.	Co-lat.	38° 42′.	½ co-lat.	19° 21′.
St. Mary's lat.	37 00.	Co-lat.	53 00.	½ co-lat.	26 30.

To ½ co-lat. 20° 30′, its log. tang. = 9,69774

To ½ co-lat. 19 21, its log. tang. = 9,54552

Difference = 1522,2 = G.

For the Courſe.

G : N :: L : T. (764)		
As G	1522	6.81759
To N		10,10151
So diff. long.	786	2,89542
To tang. Cour.	33° 07′	9,81452

For the Diſtance.

The diſtance will be the ſame as in the former computation; for the diff. of near a min. in the courſe would not happen in working by tables containing more places.

BY THE TRAVERSE TABLE.

Seek the mer. diff. lat. and diff. long. together, like diff. lat. and dep., d the courſe is given among the degrees.

Then with the courſe and proper diff. lat. find the diſt.

Thus taking $\frac{1}{20}$th of 1204 and 786, *viz.* 60,2 and 39,3; they will found together under 33° 15′ deg. for the courſe.

And taking $\frac{1}{20}$th of the diff. lat. 858, *viz.* 42,9, and the courſe 33° 15′, ves about 51⅛ for the diſt., which taken 20 times gives 1022 diſt.

PROBLEM IV.

771. Given the bearing and latitudes of two places;
Required their diſtance and difference of longitude.

Exam. *A ſhip who had taken her departure from a place in lat. 3 00′ N. long. 22° 56′ W., ſteers N. 33° 19′ E.; and cloudy weather comi on, ſhe got no obſervation till eight days after, and then found herſelf in la 51° 18′ N.: Required her true diſtance and preſent longitude?*

By Middle latitude sailing.

Departed lat.	37° 00′ N.	Sum latitudes	88° 18′
Preſent lat.	51 18 N.	Mid. lat.	44 09
Diff. lat.	14 18 = 858 m.	Co. Mid. lat.	45 51

By Construction. Fig. 10. Plate VIII.

Draw the meridian AD = 858, the diff. lat. deſcribe the quadra A*mp*; make *mc* equal to 33° 19′, the courſe: Draw DC parallel to A meeting in C, the rhumb AC drawn thro' *c*: With the ſine of the cc mid. lat. 45° 51′ deſcribe the arc EF, in which apply the dep. DC, fro E to F; thro' F draw AB, and draw the chord *m* B.

Then is AC the diſtance run, and *m* B the diff. longitude.

By Computation.

For the diſtance.

ſin. ∠C : AD :: R : AC.		
As coſ. Cou.	= 33° 19′	0,07798
To diff. lat.	= 858	2,93349
So Rad	= 90° 00′	10,00000
To diſt.	= 1027	3,01147

For the diff. longitude.

C : T :: P : L. (76c		
As coſ. m. lat.	= 45° 51′	0,1441
To tang. Cou.	= 33 19	9,8177
So diff. lat.	= 858	2,9334
To diff. long.	= 786	2,8954

Now 22° 56′ W. = Dep. long.
60) 786 (13 06 E. = Diff. long.

9 50 W. = Preſ. long.

By the Traverse Table.

1ſt. With the courſe among the degrees, and the diff. lat. in its co lumn, find the departure, and diſtance, in their columns.

2d. With the co-mid. lat. among the degrees, and departure in it column, find the diff. long. among the diſtances.

Thus taking $\frac{1}{20}$ of the diff. lat. 858, *viz.* 42,9; with it, and the cour $33\frac{1}{3}$°, the departure will be found 28,1, and the diſt. 51,3; each bein multiplied by 20, gives 562 for the depart. and 1026 for the diſtance.

The co-mid. lat. 45° 51′, or $45\frac{5}{6}$ deg. and 28,1 = $\frac{1}{20}$ departure, wil give in the column of diſtances 39,5; which multiplied by 20, give 790 for the difference of longitude.

772.

2.

BY MERCATOR'S SAILING.

eparted lat.	37° 00′ N.	Mer. parts	2393
refent lat.	51 18 N.	Mer. parts	3597
iff. lat.	14 18 = 858 m.	Mer. diff. lat.	1204

BY CONSTRUCTION. Fig. 18. Plate VIII.

raw a meridian AB, in which take AB = 1204, the mer. diff. lat., AD = 858, the proper diff. lat. Defcribe the quadrant A *m p*, and e *mc* = 33° 19′, the courfe: Thro' B and D, draw BE, DC, parallel A *p*, meeting the rhumb drawn thro' A and *c*, in the points E, C. hen is AC the diftance, and BE the diff. longitude.

COMPUTATION *by Meridional parts.*

For the diftance.			*For the diff. longitude.*		
in. ∠DCA : AB : : R : AC.			R : T : : M : L. (762)		
cof. Cou.	= 33° 19′	0,07798	As Rad	= 45° 00′	10,00000
diff. lat.	= 858	2,93349	To tan. Cou.	= 33 19	9,81776
Rad	= 90° 00′	10,00000	So m. diff. lat.	= 1204	3,08063
dift.	= 1027	3,01147	To diff. long.	= 791,4	2,89839

Now 22° 56′ W. = Dep. long.
60) 791 (13 11 E. = Diff. long.

Then 9 45 W. = Pref. long.

COMPUTATION *by Logarithmic tangents.*

eparted lat.	37° 00′ N.	Co-lat.	53° 00′.	$\frac{1}{2}$ co-lat.	26° 30′.
refent lat.	51 18 N.	Co-lat	38 42.	$\frac{1}{2}$ co-lat.	19 21.

o $\frac{1}{2}$ co-lat. 26° 30′, its log. tang. = 9,69774
o $\frac{1}{2}$ co-lat. 19 21, its log. tang. = 9,54552
Difference = 1522,2 = G.

For the diftance.	*For the diff. longitude.*		
in. ∠DCA : AB : : R : AC.	N : G : : T : L. (764)		
	As N	=	9,89849
he diftance is found as above.	To G	= 1522	3,18241
	So tang. Cou.	= 33° 19′	9,81776
	To diff. long.	= 791,8	2,89866

BY THE TRAVERSE TABLE.

Vith the courfe among the degrees, and the diff. lat. found in the comn of lat. find the diftance in its column.

ind the courfe among the degrees, and the mer. diff. lat. in the comn of lat. and take the correfponding dep. for diff. long.

ow $\frac{1}{20}$th of 858, the diff. lat., and of 1204, the mer. diff. lat., are 4 and 60,2. Then, under 33° 15′, the diff. lat. 42,9 falls between and 52 in the diftances, take it 51,5; which multiplied by 20 gives o for the diftance.

nd under 33° 15′, the mer. diff. lat. falis againft 39,48 of depart., ch multiplied by 20 gives 789,6 for the diff. longitude.

PROBLEM

PROBLEM V.

773. Given one latitude, courſe and diſtance.
Required the other latitude and diff. longitude.

Exam. *A ſhip takes her departure from a place in lat.* 51° 18′ *N. l* 9° 50′ *W.*; *and ſteers S.* 33° 08′ *W. till ſhe has run* 1024 *miles : Requ her preſent latitude and longitude?*

By Middle latitude sailing.

By Construction. Fig. 11. Plate VIII.

Draw a meridian AD, and deſcribe the quadrant A*mp*; make the *mc* = 33° 08′, the courſe: In the rhumb drawn thro' C, take AC 1024, the diſtance: Draw CD parallel to A*p*, meeting AD in D.

By Computation.

For the diff. latitude.

R : AC : : ſin. ∠C : AD.

As Rad	= 90° 00′	10,00000
To diſt.	= 1024	3,01030
So coſ. Cou.	= 33° 08′	9,92293
To diff. lat.	= 857,5	2,93323

For the diff. longitude.

As C : T : : P : L.

As coſ. m. lat.	= 45° 51′	0,14417
To tang. Cou.	= 33 08	9,81473
So diff. lat.	= 857,5	2,93323
To diff. long.	= 778,3	2,89113

Now	9° 50′ W.	= Dep. long.
60) 778 (	12 58 W.	= Diff. long.
	22 48 W.	= Preſ. long.

Now	51° 18′ N.	= Dep. la
60) 857 (	14 17 S.	= Diff. la
	37 01 N.	= Preſ. la
	88 19	= Sum lat
	44 09	= Mid. la
	45 51	= Co-m.

Then in the arc EF, deſcri with the ſin. Co. m. lat. 45°51′, ap CD from E to F : thro' F draw cutting the arc *mcp* in B; then being drawn will be the diff. lc ſought.

By the Traverse Table.

With the courſe found among the degrees, and the diſtance in column, find the dep. and diff. lat.; then find the other lat.

Seek the co-mid. lat. among the degrees, and the dep. in its col. t the correſponding diſt. is the diff. long. ſought.

Thus. Under the courſe 33° 15′, and againſt the diſt. 51, whicl the 20th part of 1024, ſtands lat. 42,65; dep. 27,96.

Then 42,65 x 20 = 853 m. = 14° 13′, the diff. lat.

Hence the preſ. lat. is 37° 05′ N.; and the co-mid. lat. 45° 48′.

Again. Over the degrees 45° 40′, the neareſt dep. to 27,96 ſta againſt 39 in the diſtances.

Then 39 x 20 = 780 m. the diff. longitude.

BY MERCATOR'S SAILING.

BY CONSTRUCTION. Fig. 19. Plate VIII.

raw the meridian AB, deſcribe the quadrant A mp; make the arc = 33° 08′, the courſe. In the rhumb AC drawn thro' c, take AC = 4 miles, the diſt.; and draw CD parallel to A p.

COMPUTATION *by Meridional parts.*

For the diff. latitude.

s Rad : AC : : ſin. ∠C : AD.
Rad = 90° 00′ 10,00000
diſt. = 1024 3,01030
cof. Cou. = 33° 08′ 9,92293
pro. diff. lat. = 857,5 2,93323

For the diff. longitude.

As R : T : : M : L.
Rad = 45° 00′ 10,00000
tang. Cou. = 33 08 9,81473
ner. d. lat. = 1203 3,08026
diff. long. = 785,2 2,89499

ow 9° 50′ W. = Dep. long.
785 (13 05 W. = Diff. long.
22 55 W. = Preſ. long.

Now 51° 18′ N. = Dep. lat.
60) 857 (14 17 S. = Diff. lat.
37 01 N. = Preſ. lat.

To 51° 18′ merid. parts = 3597
To 37 01 merid. parts = 2394
Merid. diff. lat. = 1203

Make AB = 1203; thro' B draw BE parallel to A p, meeting AC continued in E; then BE is the diff. longitude.

COMPUTATION *by Logarithmic tangents.*

he diff. lat. and preſent lat. being found as above.

ep. lat. 51° 18′. Co-lat. 38° 42′. $\frac{1}{2}$ co-lat. 19° 21′.
ref. lat. 37 01. Co-lat. 52 59. $\frac{1}{2}$ co-lat. 26 29$\frac{1}{2}$.

o $\frac{1}{2}$ co-lat. 26° 29$\frac{1}{2}$′, its log. tang. = 9,69758
o $\frac{1}{2}$ co-lat. 19 21, its log. tang. = 9,54552
Difference = 1520,6 = G.

As N : G : : T : L.
N = 9,89849
G = 1521 3,18213
ang. Cou. = 33° 08′ 9,81473
diff. long. = 785,9 2,89535

Now 9° 50′ W. = Dep. long.
60) 786 (13 06 W. = Diff. long.
22 56 W. = Preſ. long.

BY THE TRAVERSE TABLE.

Vith the courſe and diſtance, find the diff. latitude.

nd then get the preſent lat. and the mer. diff. latitude.

Vith the courſe, and the mer. diff. lat. taken in the column of Lat. correſponding dep. will be the diff. longitude.

ow $\frac{1}{20}$th of the diſt. 1024 is 51,2. Then under the courſe 33° 15′, nſt 51 among the diſtances, ſtands 42,65 in col. of Lat. And 42,65 0 gives 853; ſo the diff. lat. is 14° 13′; the preſent lat. is 37° 05′ N. the mer. diff. lat. is 1198; $\frac{1}{20}$th of which is 59,9.

o the courſe 33° 15′, againſt lat. 59,9, or its neareſt 60,21, ſtands 39,48; which multiplied by 20 gives 789,6 for the diff. long. required.

PROBLEM

PROBLEM VI.

775. Given the latitudes of two places, and their diſtance. Required their bearing, and difference of longitude.

Exam. *A ſhip in lat.* 51° 18′ *N., long.* 22° 06′ *W., is bound to a pl in the SE. quarter, diſtant* 1024 *miles, and in lat.* 37° 00′ *N.: What is direct courſe, and how much muſt ſhe alter her long. to arrive at the deſt port?*

By Middle latitude sailing.

Lat. from	51° 18′ N.	
Lat. to	37 00 N.	
Diff. lat.	14 18	= 858 miles.

Sum latitudes	88° 18′
Middle latitude	44 09
Co-middle latitude	45 51

By Construction. Fig. 12. Plate VIII.

Draw the meridian AD = 858 miles; deſcribe the quadrant A m From A with 1024 miles, the given diſtance, cut DC drawn parallel A *p*, in C; draw AC. In the arc EF deſcribed with the ſine of 45° 5 the co-middle lat., apply DC the departure from E to F; thro' F dr AB, and draw the chord B *m*.

Then the courſe is meaſured by the arc *m c*; and the diff. long. by t line *m* B.

By Computation.

For the Courſe.

AC : Rad :: AD : ſin.∠C.

As diſt.	=	1024	6,98970
To Rad	=	90° 00′	10,00000
So diff. lat.	=	858	2,93349
To coſ. Cou.	=	33° 05′	9,92319

Courſe SE. b. S. nearly.

For the diff. longitude.

C : T :: P : L.

As coſ. m. lat.	=	45° 51′	0,144
To tang. Cou.	=	33 05	9,813
So diff. lat.	=	858	2,933
To diff. long.	=	779	2,891

Now	22° 06′ W.	=	Long. fro
60) 779 (	12 59 E.	=	Diff. long
	9 07 W.	=	Preſ. long

By the Traverse Table.

With the diſtance and diff. lat. in their columns, find the courſe amo the degrees, and the dep. in its column.

With the co-middle lat. among the degrees, and the dep. in its c lumn, find the diff. long. among the diſtances.

Thus. To the diſt. 51, and the lat. 42,77, the neareſt to 51,2 a 42,9, being the 20th parts of the diſt. 1024 and diff. lat. 858; t courſe is 33° 00′, and the dep. 27,8.

With the co-middle lat. 45° 51′, or 46°, againſt the dep. 27,8 ſtan 39 in the col. of diſt., which multiplied by 20 gives 780 for the di long.

Note, The lat. 42,77 is preferred to the lat. 42,89, which is nearer 42,9; becauſe taking the proportion between 51 and 51,2, the lat. the former caſe comes nearer to 42,9 than in the latter caſe.

6.

By Mercator's sailing.

at. from	51° 18′ N.	Mer. parts	=	3597
at. to	37 00 N.	Mer. parts	=	2393
iff. lat.	14 18 = 858 m.	Mer. diff. lat.	=	1204

By Construction. Fig. 20. Plate VIII.

n the meridian AB, take AB = 1204, the merid. diff. lat. and AD 858, the proper diff. lat.: Deſcribe the quadrant A *m p*; from A, n the diſtance 1024, cut DC, drawn parallel to A *p*, in C; draw AC; ich continue till it meets BE, drawn parallel to A *p*, in E.

Then BE = diff. long. and arc *m c* meaſures the courſe.

Computation *by Meridional parts.*

For the Courſe.

C : Rad : : AD : ſ. ∠ACD.

iſt.	=	1024	6,98970
Rad	=	90° 00′	10,00000
. diff. lat.	=	858	2,93349
oſ. Cou.	=	33° 05′	9,92319

ourſe SE. by S. nearly.

For the diff. longitude.

Rad : T : : M : L.

As Rad	=	45° 00′	10,00000
To tan. Cou.	=	33 05	9,81390
So m. diff. lat.	=	1204	3,08063
To diff long.	=	784,4	2,89453

Now 22° 06′ W. = Long. from
60) 784 (13 04 E. = Diff. long.
9 02 W. = Long. to.

Computation *by the Logarithmic tangents.*

epart. lat.	51° 18′.	Co-lat.	38° 42′.	½ co-lat.	19° 21′.
t. bound to	37 00.	Co-lat.	53 00.	½ co-lat.	26 30.

o ½ co-lat. 26° 30′, its log. tang.	=	9,69774	
o ½ co-lat. 19 21, its log. tang.	=	9,54552	
Difference	=	1522,2	= G.

For the Courſe.

C : Rad : : AD : ſ. ∠ACD.

ourſe is S. 33° 05′ E. as above.

For the diff. longitude.

N : G : : T : L.

As N	=		9,85849
To G	=	1522	3,18241
So tang. Cou.	=	33° 05′	9,81390
To diff. long.	=	784,9	2,89480

By the Traverse Table.

ith the diſtance and diff. lat. in their columns, find the courſe among the degrees.

ith the courſe among the degrees, and the mer. diff. lat. in the col. of t. find the diff. long. in the col. of departure.

he courſe found as before is 33° 00′.

nd $\frac{1}{20}$th of the mer. diff. lat. *viz.* 60,2, found under 33° in the col. of t., the neareſt correſponding dep. is 39,21; which multiplied by 20 ives 784,2 for the diff. longitude.

PROBLEM VII.

777. Given the latitudes of two places, and the departure.
Required the courſe, diſtance, and difference of longitude.

Exam. *A ſhip from the latitude 37° 00′ N., longitude 48° 20′ W. ſails between the N. and E., and being come to the lat. 51° 18′ N., fin ſhe has made 564 miles of departure: What was her direct courſe, diſtan run, and preſent longitude?*

By Middle latitude sailing.

Preſent lat.	51° 18′ N.	Sum latitudes	88° 18′
Departed lat.	37 00 N.		
		Mid. lat.	44 09
Diff. lat.	14 18 = 858 m.		
		Co. Mid. lat.	45 51

By Construction. Fig. 13. Plate VIII.

In a meridian line, take AD = 858 m., the diff. lat. Deſcribe the qu drant A mp, and parallel to A p draw DC = 564 m. the departure; al draw the diſtance AC: In the arc EF, deſcribed with the ſine of the co-mi lat. 45° 51′, apply the chord EF equal to DC; thro' F draw AB; th the chord mB will be the diff. long., and the arc mc meaſures t courſe.

By Computation.

To find the Courſe.

AD : DC : : Rad : t.∠DAC.

As diff. lat.	=	858	7,06651
To Depart.	=	564	2,75128
So Rad	=	45° 00′	10,00000
To tang. Cou.	=	33 19	9,81779

To find the Diſtance.

ſin.∠DAC : DC : : Rad : AC.

As ſin. Cou.	=	33° 19′	0,260
To Depart.	=	564	2,751
So Rad	=	90° 00′	10,000
To Diſt.	=	1027	3,011

To find the diff. longitude.

C : R : : D : L.

As coſ. m. lat.	=	45° 51′	0,14417
To Rad	=	90 00	10,00000
So Depart.	=	564	2,75128
To diff. long.	=	786	2,89545

Or C : T : : P : L.

Now 48° 20′ W. = Dep. lo
60) 786 (13 06 E. = Diff. lo
35 14 W. = Preſ. lo

Courſe NE. b. N. nearly.

By the Traverse Table.

The diff. lat. and dep. being found together, will give the cou among the degrees, and the diſtance in its column.

With the co-mid. lat. among the degrees, and the dep. in its c find the diff. longitude among the diſtances.

Now $\frac{1}{20}$th of 858, the diff. lat., and of 564, the dep., are 42,9 a 28,2. The neareſt numbers to theſe are found together under the cou 33° 30′, and to the diſtance 51; which multiplied by 20 gives 1020.

Alſo the dep. 28,2 being found to the co-mid. lat. 46°, gives 3 which multiplied by 20 gives 780 for the diff. longitude.

But the parts being proportioned, gives 51,2 for the diſt.; and 3 for the diff. long.; theſe multiplied by 20, give 1024 and 784.

7

78.

BY MERCATOR'S SAILING.

Preſent lat.	51° 18′ N.	Mer. parts	3597
Departed lat.	37 00 N.	Mer. parts	2393
Diff. lat.	14 18 = 858 m.	Mer. diff. lat.	1204

BY CONSTRUCTION. Fig. 21. Plate VIII.

In a meridian line take AB = 1204 m., the merid. diff. lat.; and D = 858 m., the prop. diff. lat. Deſcribe the quadrant A *mp*; thro' draw DC parallel to A *p*, and make DC = 564 m., the dep. Thro' draw AE meeting BE drawn parallel to A *p*.

Then is AC the diſt., BE the diff. long.; and the arc *mc* meaſures e courſe.

COMPUTATION *by Meridional parts.*

For the Courſe.

AD : DC :: Rad : t.∠DAC.

diff. lat.	= 858	7,06651
Depart.	= 564	2,75128
Rad	= 45° 00′	10,00000
tang. Cou.	= 33 19	9,81779

For the Diſtance.

ſin.∠DAC : DC :: Rad : AC.

As ſin. Cou.	= 33° 19′	0,26022
To Depart.	= 564	2,75128
So Rad	= 90° 00′	10,00000
To Diſt.	= 1027	3,01150

For the diff. long. P : D :: M : L. Or R : T :: M : L.

prop. diff. lat.	= 858	7,06651
Depart.	= 564	2,75128
mer. diff. lat.	= 1204	3,08063
diff. long.	= 791,5	2,89842

Now 48° 20′ W. = Dep. long.
60) 791 (13 11 E. = Diff. long.
35 09 W. = Preſ. long.

Courſe NE. b. N. nearly.

COMPUTATION *by Logarithmic tangents.*

Departed lat.	37° 00′ N.	Co-lat.	53° 00′.	$\frac{1}{2}$ co-lat.	26° 30′.
Preſent lat.	51 18 N.	Co-lat	38 42.	$\frac{1}{2}$ co-lat.	19 21.

10 $\frac{1}{2}$ co-lat. 26° 30′, its log. tang. = 9,69774
To $\frac{1}{2}$ co-lat. 19 21, its log. tang. = 9,54552
Difference = 1522,2 = G.

The courſe and diſtance are found above.

For the diff. longitude.

N : G :: T : L.

As N	=	9,89849
To G	= 1522	3,18241
So tang. Cou.	= 33° 19′	9,81776
To diff. long.	= 791,9	2,89866

BY THE TRAVERSE TABLE.

The courſe found as before is 30° 30′; under which againſt 60,2 (= $\frac{1}{20}$th of the mer. diff. lat.) in the col. of lat., ſtands 39,74 in the l. of dep. Then 39,74 × 20 = 794,8, the diff. longitude.

PROBLEM VIII.

779. Given one latitude, the courſe and departure;
Required the other latitude, diſtance, and diff. longitude.

Exam. *A ſhip from the latitude* 51° 18′ *N., longitude* 9° 50′ *W., ſa* S. 33° 19′ *W. until her departure is* 564 *miles: Required her preſent la tude, longitude and diſtance?*

By Middle latitude sailing.

By Construction. Fig. 14. Plate VIII.

Draw a meridian line AD, deſcribe the quadrant A*mp*; make A*a*: 564, the departure, and the arc *mc* = 33° 19′, the courſe; thro' draw the rhumb AC meeting *a*C, drawn parallel to AD, in C; a draw CD parallel to A*p*.

By Computation.

For the diff. latitude.

ſin.∠DAC : CD : : ſin.∠ACD : AD.

As ſin. Cou.	=	33° 19′	0,26022
To Depart.	=	564	2,75128
So coſ. Cou.	=	33° 19′	9,92202
To diff. lat.	=	858	2,93352

Now	51°	18′	N.	=	Dep. lat.
60) 858 (	14	18	S.	=	Diff. lat.
	37	00	N.	=	Preſ. lat.
	88	18		=	Sum lats.
	44	09		=	Mid. lat.
	45	51		=	Co-m. l

Then in the arc EF, deſcribed with the ſine of 45° 51′, apply from E to F: thro' F draw AB; and draw the diff. long. B*m*.

To find the Diſtance.

ſin. ∠DAC : CD : : Rad : AC.

As ſin. Cour.	=	33° 19′	0,26022
To Depart.	=	564	2,75128
So Rad	=	90° 00′	10,00000
To Diſt.	=	1027	3,01150

To find the diff. longitude.

As C : Rad : : D : L.

As coſ. m. lat.	=	45° 51′	0,144
To Rad	=	90 00	10,000
So Depart.	=	564	2,751
To diff. long.	=	786	2,895

Now	9°	50′	W.	=	Dep.long.
60) 786 (	13	06	W.	=	Diff. long.
	22	56	W.	=	Preſ. long.

By the Traverse Table.

With the courſe (33° 15′ the neareſt to 33° 19′) and the depa (28,2 = $\frac{1}{20}$th of 564) in its column, find in the col. of lat. the di lat. (42,53) and in the col. of diſt. find the diſt. (51).

Then 42,53 × 20 = 850,6; and 51 × 20 = 1020.

Hence the preſent lat. is 37° 07′ N., and the co-mid. lat. 45° 48′.

The co-mid. lat. 45,40 and dep. 28,2 gives in the column of ſtances 39, which multiplied by 20, gives 780, for the diff. of longitu

But proportioning for the difference, gives 39,2; and 39,2 × 20 784, for the diff. longitude.

78

0. **By Mercator's sailing.**

By Construction. Fig. 22. Plate VIII.

Draw a meridian line AB; deſcribe the quadrant A *m p*; make A *a* = 564, and the arc *m c* = 33° 19′; draw *a* c parallel to AB meeting t rhumb AC, drawn thro' *c*, in C; and draw the departure CD parallel t A *p*.

Computation *by Meridional parts.*

For the diff. latitude.

ſi ∠DAC : CD :: ſin. ∠DCA : AD.

A ſin. Cou.	=	33° 19′	0,26022
T Depart.	=	564	2,75128
S coſ. Cou.	=	33° 19′	9.92202
T diff. lat.	=	858	2,93352

Now 51° 18′ N. = Dep. lat.
60) 858 (14 18 S. = Diff. lat.
37 00 N. = Preſ. lat.
To 51° 18′ merid. parts = 3598
To 37 00 merid. parts = 2394
Merid. diff. lat. = 1204

Then make AB = 1204; draw BE parallel to A *p*, meeting AC con- t ued, in E; and BE is the diff. of longitude.

To find the Diſtance.

; ſin. ∠DAC : DC :: Rad : AC.

A ſin. Cou.	=	33° 19′	0,26022
T Depart.	=	564	2,75128
S Rad	=	90° 00′	10,00000
T Diſt.	=	1027	3,01150

To find the diff. longitude.

P : D :: M : L.

As p. diff. lat.	=	858	7,06651
To Depart.	=	564	2,75128
So mer. diff. lat.	=	1204	3,08063
To diff. long.	=	791,4	2,89842

Now 9° 50′ W. = Dep. long.
60) 791 (13 11 W. = Diff. long.
23 01 W. = Preſ. long.

Computation *by Logarithmic tangents.*

Find the diff. latitude and preſent latitude as above.

Then, Dep. lat.	51°	18′.	Co-lat.	38°	42′.	$\frac{1}{2}$ co-lat.	19°	21′.
Preſ. lat.	37	00.	Co-lat.	53	00.	$\frac{1}{2}$ co-lat.	26	30.

To $\frac{1}{2}$ co-lat. 26° 30′, the log. tang. is = 9,69774
To $\frac{1}{2}$ co-lat. 19 21, the log. tang. is = 9,54552
Difference = 1522,2 = G.

To find the diff. longitude. N : G :: T : L.

A N	=		9,89849
T G	=	1522	3,18241
S tang. Cou.	=	33° 19′	9,81776
T diff. long.	=	791,8	2,89866

The diſtance and preſent longitude may be found as above.

By the Traverse Table.

Find as before the diff. lat. = 851; and the diſtance = 1020.

Then the preſent lat. is 37° 07′ N.; and the mer. diff. lat. is 1197; th of which is 59,85.

Now under the courſe 33° 15′, and againſt 60,21, the neareſt to 5,85 in the col. of lat., ſtands in the col. of dep. 39,48; which multi ied by 20, gives 789,6 for the diff. longitude.

PROBLEM

PROBLEM IX.

781. Given one latitude, the diſtance and departure;
Required the other latitude, courſe and diff. longitude.

EXAM. *A ſhip from the latitude* 37° 00′ *N., longitude* 9° 02′ *W., h ing ſailed between the N. and W.* 1027 *miles, reckons ſhe has made* 5 *miles of departure: What was her direct courſe, and the preſent latit and longitude?*

BY MIDDLE LATITUDE SAILING.

BY CONSTRUCTION. Fig. 15. Plate VIII.

Draw the meridian line AD; deſcribe the quadrant A*mp*; make = 564 m.; from A with 1027, the diſtance, cut *a*C drawn paralle AD in C; draw AC, and draw the departure CD parallel to A*p*.

BY COMPUTATION.

To find the Courſe.

AC : Rad : : CD : ſin.∠DAC.

As Diſt.	=	1027	6,98843
To Rad	=	90° 00′	10,00000
So Depart.	=	564	2,75128
To ſin. Cour.	=	33° 19′	9,73971

Now	37° 00′ N.	=	Dep. lat.
60) 858 (	14 18 N.	=	Diff. lat.
	51 18 N.	=	Preſ. lat.

To find the diff. latitude.

Rad : AC : : ſin.∠DCA : AI

As Rad	=	90° 00′	10,00
To Diſt.	=	1027	3,01
So coſ. Cou.	=	33° 19′	9,92
To diff. lat.	=	858,2	2,93

Sum latitudes	88° 18′
Mid. lat.	44 09
Co. Mid. lat.	45 51

Then deſcribe the arc EF with the ſine of 45° 51′, and therein ap CD from E to F; thro' F draw AB; and draw the diff. long. B*m*.

To find the diff. longitude.

As coſ. m. lat.	=	45° 51′	0,14417
To tang. Cour.	=	33 19	9,81776
So diff. lat.	=	858,2	2,93359
To diff. long.	=	786,2	2,89552

C : T : : P : L.

Now	9° 02′ W.	=	Dep. lor
60) 786 (	13 06 W.	=	Diff. lon
	22 08 W.	=	Preſ. lon

Courſe is NW. b. N. nearly.

BY THE TRAVERSE TABLE.

Now $\frac{1}{20}$th of the diſtance, and of the dep., are 51,35, and 28,2.

Find in ſome column of departure, the neareſt number to the giv departure (28,2) ſtanding againſt the given diſtance (51); which tl gives the courſe (33° 30′) among the degrees; and the diff. lat. (42,5 in its column.

Then 42,55 × 20 = 850,6: Hence the preſ. lat. is 51° 11′ N.; a the co-mid. lat. is 45° 55′.

With the neareſt co-mid. lat. (46°) and the dep. (28,2) find amo the diſtances (39) the diff. longitude.

Then 39 × 20 = 780, for the diff. longitude.

But by proportioning the parts, the diff. lat. will be found to be 85 and the diff. long. 784.

7

By Mercator's sailing.

By Construction. Fig. 23. Plate VIII.

raw a meridian AB; deſcribe a quadrant A *m p*; make A *a* = 564; w *a* C parallel to AB; from A with 1027, the diſtance, cut *a* C in draw the departure CD parallel to A *p*, and draw the diſtance AC.

Computation *by Meridional parts.*

To find the Courſe.

C : Rad : : CD : ſin.∠DAC.

A Diſt.	=	1027	6,98843
T Rad	=	90° 00′	10,00000
Sc Depart.	=	564	2,75128
T ſin. Cou.	=	33° 19′	9,73971

ow 37° 00′ N. = Dep. lat.
858 (14 18 N. = Diff. lat.
51 18 N. = Preſ. lat.

To find the diff. latitude.

Rad : AC : : ſin.∠DCA : AD.

As Rad	=	90° 00′	10,00000
To Diſt.	=	1027	3,01157
To coſ. Cou.	=	33° 05′	9,92202
To diff. lat.	=	858,2	2,93359

To 51° 18′, the mer. parts = 3598
To 37 00, the mer. parts = 2394
Mer. diff. lat. = 1204.

hen make AB = 1024; continue AC till it meets BE drawn parallel A *p*; and BE is the diff. longitude.

To find the diff. longitude.

A Rad	=	45° 00′	10,00000
T tan. Cou.	=	33 19	9,81776
S n. diff. lat.	=	1204	3,08063
T diff. long.	=	791,4	2,89839

Rad : T : : M : L.

Now 9° 02′ W. = Dep. long.
60) 791 (13 11 W. = Diff. long.
22 13 W. = Preſ. long.

Courſe NW. b. N. nearly.

Computation *by Logarithmic tangents.*

ind the courſe and preſent latitude as above.

hen,	Dep. lat.	37° 00′.	Co-lat.	53° 00′.	½ co-lat.	26° 30′.
	Preſ. lat.	51 18.	Co-lat.	38 42.	½ co-lat.	19 21.

o ½ co-lat. 26° 30′, the log. tang. is = 9,69774
o ½ co-lat. 19 21, the log. tang. is = 9,54552
Difference is = 1522,2 = G.

To find the diff. longitude.

N : G : : T : L.

A N	=		9,89849
T G.	=	1552	3,18241
S tang. Cou.	=	33° 19′	9,81776
T diff. long.	=	791,8	2,89866

The preſent longitude may be found as above.

By the Traverse Table.

ind as before, by proportioning the parts, the diff. lat. = 856, and t courſe N. 33° 30′ W.

ence the preſent lat. is 51° 16′ N.; and the mer. diff. lat. = 1200, h whereof is 60.

Then in the col. of lat., under 33° 30′, find 60,04, the neareſt to 6; againſt which, in the departure, ſtands 39,74; which multiplied 20, gives 794,8 for the diff. longitude.

PROBLEM

PROBLEM X.

783. Given one latitude, departure and diff. longitude;
Required the other latitude, courſe and diſtance.

Exam. *A ſhip from the latitude* 51° 18′ *N., longitude* 22° 06′ *W having ſailed between the S. and E. for ſeveral days, reckons ſhe has ma* 564 *miles of departure, and* 786 *miles of longitude: What is the lat. a long. of the place arrived at, and alſo her direct courſe and diſtance?*

By Middle latitude sailing.

By Construction. Fig. 16. Plate VIII.

Draw a meridian AD; deſcribe the quadrant A*mp*; in the arc *m* apply the chord *m*B = 786, the diff. long.; draw AB; make *ma* = 564; draw *a*F parallel to A*m*, and with the radius AF deſcribe the a FE, and draw the chord EF.

Then is EF = departure, and AE = ſine of the co-mid. lat.

By Computation.

To find the co-mid. latitude.

L : D :: Rad : C.

As diff. long.	= 786	7,10458
To Depart.	= 564	2,75128
So Rad	= 90° 00′	10,00000
To coſ. m. lat.	= 45 51	9,85586

Now Co-mid. lat. = 45° 51′
Middle lat. = 44 09
Sum lats. = 88 18
Depart. lat. = 51 18
Preſent lat. = 37 00
Differ. lat. = 14 18 = 858

Make AD = 858; draw DC parallel to A*p*, and equal to EF; the AC being drawn will be the diſtance; and ∠DAC the courſe.

To find the Courſe.

P : L :: C : T.

As diff. lat.	= 858	7,06651
To diff. long.	= 786	2,89542
So coſ. m. lat.	= 45° 51′	9,85583
To tang. Cou.	= 33 19	9,81776

Now 22° 06′ W. = Dep. long.
60) 786 (13 06 E. = Diff. long.
9 00 W. = Preſ. long.

To find the Diſtance.

ſin. ∠DAC : DC :: Rad : AC.

As ſin. Cou.	= 33° 19′	0,2602
To Depart.	= 564	2,7512
So Rad	= 90° 00′	10,0000
To Diſt.	= 1027	3,0115

The Courſe is SE. b. S. nearly,
Diſtance 1027 miles.
Preſent lat. 37° 00′ N.

By the Traverse Table.

Now $\frac{1}{20}$th of the diff. long. and dep. are 39,3 and 28,2.

Seek in the table, till the given dep. 28,2 is found in its col. again the given diff. long. 39 in the col. of diſtances; and it gives the co mid. lat. among the degrees.

Here 28,2 falls between 28,05 over 46°, and 27,89 over 45° 40′ therefore taking the co-mid. lat. = 45° 50′, the preſent lat. is 37° 0 N.; the diff. lat. is 856; and its $\frac{1}{20}$th is 42,8.

Then 42,8 and 28,2 will be found together under 33° 30′, the cour and between 51 and 52 in the diſtances; ſuppoſe 51,2, which multipli by 20, gives 1024 for the diſtance. 784

PROBLEM XI.

784. Given one latitude, courſe and difference of longitude; Required the other latitude and diſtance.

EXAM. *A ſhip from the lat.* 37° 00′ *N., long.* 22° 56′ *W., runs on courſe N.* 33° 19′ *E. until ſhe finds her diff. longitude is* 786 *miles: hat is her preſent latitude and diſtance ſailed?*

This problem cannot be reſolved by Middle latitude ſailing.

By Mercator's sailing.

By Construction Fig. 24. Plate VIII.

Draw the meridian AB; deſcribe the quadrant A *mp*; continue A *p* A*a* = 786 miles, the diff. long., and draw *a* E parallel to AB, ake the arc *mc* = 33° 19′; draw the rhumb A *c* till it meets *a* E in and draw EB parallel to A *p*.

Computation *by Meridional parts.*

To find the Mer. diff. latitude.

T : R :: L : M.		
A tan. Cou.	= 33° 19′	0,18224
T Rad	= 45 00	10,00000
S diff. long.	= 786	2,89542
T m. diff. lat.	= 1196	3,07766

Dep. lat.	37° 00′ N.	Mer. pts.	2394
		Mer d. lat.	1196
Preſ. lat.	51 14 N.	M. pts.	3590
Diff. lat.	14 14 = 854 miles.		

Make AD = 854, draw DC parallel to A *p*; then AC is the diſtance.

To find the diſtance. ſin.∠DCA : AD :: Rad : AC.

A coſ Cou.	= 33° 19′	0,07798
T diff. lat.	= 854	2,93146
S Rad	= 90° 00′	10,00000
T Diſt.	= 1022	3 00944

Computation *by Logarithmic tangents.*

To find the preſent latitude.

T : L :: N : G.		
A tang. Cou.	= 33° 19′	0,18224
T diff. long.	= 786	2,89542
S	=	10,10151
T G	= 1511	3,17917

Dep. lat.	37° 00′.	Co-lat.	53° 00′.
$\frac{1}{2}$ co-lat.	26 30.	L. tan.	9,69774
		G =	1511
$\frac{1}{2}$ co-lat.	19 24.	L. tan.	9,54664
Co-lat.	38 48.		

Therefore the preſ. lat. is 51° 12′ N.

By the Traverse Table.

eek the diff. long. in the col. of dep. to the given courſe, and it s in the col. of lat. the mer. diff. lat.

hus under 33° 15′, againſt 39,3 (= $\frac{1}{20}$th of 786) in the dep. ſtands 5938; or by proportioning, 59,86, which multiplied by 20, gives 117 for the mer. diff. lat. Hence the preſent lat. is 51′ 14′ N.; and diff. lat. 854; its $\frac{1}{20}$th is 42,7.

hen under 33° 15′, 42,7 in the col. of lat. ſtands againſt 51 in the of diſtances; which multiplied by 20, gives 1020 for the diſtance.

SECTION V.

785. *Of compound Courſes corrected by Longitude.*

How to ſolve compound courſes, or Traverſes, on the principle plane ſailing, has been already ſhewn: But it is neceſſary alſo, to ſ how the proper allowances for longitude are to be introduced i ſuch accounts; which is uſually done by the following methods.

RULE I.

786. 1ſt. Complete the Traverſe table to each courſe and diſta and find the whole difference of latitude, departure and preſent latitu

2d. Then with the departed latitude, and preſent latitude, find co-middle latitude; with which, and the departure, find the courſe, ſtance, and difference of longitude, as in a ſingle courſe. By Pr VII. (7

But the longitude arrived in, is more accurately found by the foll ing

RULE II.

787. 1ſt. Complete the Traverſe table as before.

2d. Make a table of ſeven columns, title them Dep. lats., Preſ. l Sum lats., Mid. lats., Co-mid. lats., $\frac{\text{diff. longit.}}{\text{E.} \mid \text{W.}}$.

3d. By the ſeveral differences of latitude in the Traverſe table, up the firſt and ſecond columns, and hence the correſponding ſum l mid. lats., and co-mid. lats. will be obtained. (7

4th. With each correſponding co-mid. lat. and departure, find the ference of longitude to each courſe, and ſet them in columns ma E. W., according to the name of the departure uſed.

5th. Add up both the eaſt and weſt columns of longitude, and difference of their ſums will be the whole difference of longitude.

The firſt of theſe rules gives the method commonly practiſed at but the latter is more to be truſted to, eſpecially if there are fe courſes concerned.

788. EXAMPLE I. *Suppoſe a ſhip from the latitude* 52° 20′ *N.*, *gitude* 14° 38′ *W.*, *has ſailed the following courſes, viz.*

1ſt. ESE. 43 m. 2d. SW. 32 m. 3d. SE.b.S. 58 m. 4th. SSW. 6

Required her preſent latitude and longitude?

BY THE FIRST RULE.

The TRAVERSE TABLE.

Courſes.	Dif.	N.	S.	E.	W.
ESE.	43		16,5	39,7	
SW.	32		22,6		22,6
SE. b. S.	58		48,2	32,2	
SSW.	60		55,4		23,0
			142,7	71,9	45,6
				45,6	
				26,3	

To find the diff. longitude.

BY MIDDLE LATITUDE.

ep. lat. = 52° 20′ N.
iff. lat. = 2 23 S.

eſent lat. = 49 57 N.

ım of lats. = 102 17

id. lat. = 51 08
o-mid. lat. = 38 52

epart. long. = 14 38 W.
iff. long. = 0 42 E. (777)

eſent long. = 13 56 W.

BY MERCATOR.

Dep. lat. 52° 20′ N. Mer. pts. 3698
Preſ. lat. 49 57 N. Mer. pts, 3470

Mer. diff. lat. 228

P : D :: M : L.

As prop. diff. lat. = 142,7 7,84558
To Depart. = 26,3 1,41996
So mer. diff. lat. = 228 2,35793

To diff. long. = 42,02 1,62347

BY THE SECOND RULE.

Working by middle latitude.

The Traverſe table being made as above.

Dep. lats.	Preſent lats.	Sum lats.	Mid. lat.	Co mid lat.	Differ. longit.	
					E.	W.
52° 20′	52° 04′	104° 24′	52° 12′	37° 48′	1° 05′	° ′
52 04	51 41	103 45	51 52	38 08		0 37
51 41	50 53	102 34	51 17	38 43	0 51	
50 53	49 58	100 51	50 26	39 34		0 36
					1 50	1 13
					1 13	
					0 43	

The diff. longitude found by this method ifers from the firſt, by only 1 min.

Here, in the col. ſigned Dep. lat., the lat. ſailed from is entered, nich is 52° 20′ ; from whence the firſt diff. lat. 16′ S. being taken, lives 52° 04′ N. for the preſent lat., which, with regard to the next urſe, is a departed lat. alſo; therefore it is put alſo among the dep. ls. Then the next diff. lat. 22,6 m., or rather 23 m., being taken from the laſt departed lat., leaves 51° 41′ for the next preſ. lat.; and procee in this manner until the preſent latitude is found at the end of th courſes: Then take the ſums of thoſe departed and preſent latitud ſtanding againſt one another; alſo let the mid. latitudes and co-mid. la titudes be wrote in the columns as there titled: And then with thei co-mid. latitudes and the correſponding departures, found before in th Traverſe table, find the reſpective differences of longitude (777), whic put in their proper columns. And hence the whole difference of lon gitude is readily found.

By the second Rule.

Working by Mercator.

The Table.

Courſes.	Diſt.	N.	S.	Succeſſiv latit.	Mer. parts.	M. diff lat.	Diff. long E.	W.
				52° 20′N	3697,8			
ESE.	43		16,5	52 04	3671,7	26,1	63,0	
SW.	32		22,6	51 41	3634,4	37,3		37,3
SE. b. S.	58		48,2	50 53	3557,7	76,7	51,2	
SSW.	60		55,4	49 58	3471,4	86,3		35,7
							114,2	73,0
							73,0	
							41,2	D.lon.

Here the diff. longitude is nearly the ſame as before.

In this operation the departures are not wanted, therefore only tl differences of latitude are found in the traverſe; and with theſe tl column of ſucceſſive latitudes are eaſily filled: To theſe let the mer dional parts be taken, and their differences, as in the columns; the with the courſes, and the meridional diff. latitudes, the differences longitudes are found as directed in art. 772.

From all theſe operations it appears, that in forming the account a day's work, in almoſt any latitude, the difference of the reſult b either method, working by Mercator or by Middle latitude, is ſo ve inconſiderable, that it is indifferent which of them is uſed; eſpecial if theſe accounts are corrected by proper obſervations made as often it ſhall be thought convenient, or as they can be obtained.

However, that the mariner may have a further proof of the agreeme between the different methods propoſed, the following example, in l titudes as high as moſt navigations are performed, is here annexed.

789. Example II. *Suppoſe a ſhip from the latitude* 67° 30′ *N., lon-ude* 8° 46′ *W., has ſailed the following courſes, viz.*

NE. 64 m. NNE. 50 m. NW. b. N. 58 m. WNW. 72 m.
Weſt 48 m. SSW. 38 m. S. b. E. 45 m. ESE. 40 m.

Required her preſent latitude and longitude?

By Middle latitude, according to the ſecond rule.

Courſes.	Dif.	Diff. lats.		Depart.		Succeſſ. lats.	Sum lats.	Mid. lat.	Co.m. lat.	D. long.	
		N.	S.	E.	W.					E.	W.
						67° 30′	° ′	° ′	° ′		
E.	64	45,3		45,3		68 15	135 45	67 52	22 08	120	
NE.	50	46,2		19,1		69 01	137 16	68 38	21 22	53	
W. b. N.	58	48,2			32,2	69 49	138 50	69 25	20 35		92
NW.	72	27,6			66,5	70 17	140 06	70 03	19 57		195
eſt	48				48,0	70 17	140 34	70 17	19 43		142
SW.	38		35,1		14,5	69 42	139 59	69 59	20 01		42
. b. E.	45		44,1	8,8		68 58	138 40	69 20	20 40	25	
SE.	40		15,3	36,9		68 43	137 41	68 50	21 10	102	
		167,3	94,5	110,1	161,2					300	471
		94,5			110,1						300
Diff. lat.		72,8		Depart.	51,1				Diff. longit.		171

By Mercator, according to the ſecond rule.

Courſes.	Dif.	Diff. lat.		Depart.		Succeſſ. lats.	Mer. parts.	Mer. d. lat.	D. longit.	
		N.	S.	E.	W.				E.	W.
						67° 30′	5551,6			
E.	64	45,3		45,3		68 15	5671,1	119,5	119,5	
NE.	50	46,2		19,1		69 01	5797,3	126,2	52,4	
W. b. N.	58	48,2			32,2	69 49	5933,9	136,6		91,1
NW.	72	27,6			66,5	70 17	6016,0	82,1		198,6
eſt.	48				48,0	70 17	6016,0	00,0		142,*
W.	38		35,1		14,5	69 42	5913,7	102,3		42,4
b. E.	45		44,1	8,8		68 58	5789,0	124,7	24,8	
E.	40		15,3	36,0		68 43	5747,4	41,6	100,7	
		167,3	94,5	110,1	161,2				297,4	474,1
		94,5			110,1					297,4
Diff. lat.		72,8		Depart.	51,1			Diff. longit.		176,7

eparted lat.	67° 30′ N.	Depart. long.	8° 46′ W.
ifferent lat.	1 13 N.	Diff. long.	2 56 W.
reſent lat.	68 43 N.	Preſent long.	11 42 W.

According to the firſt rule.

The co-mid. lat. between the firſt and laſt lats. is 21° 54′, with which, and the departure 51,1, the diff. long. will be 137 miles.

Alſo, the mer. diff. lat. between the firſt and laſt lats. is 195,8; with which, and the diff. lat. 72,8, and the dep. 51,1, gives a diff. long. 137,1.

---

* This diff. long. is found by art. 751.

Example

790. Example III. *Suppoſe a ſhip from the latitude of* 68° 38′ *longitude* 8° 40′ *E., has ſailed the following courſes, viz.*

NE. b. N.	63 m.	NE.	38 m.	NNE.	56
North	30 m.	NW. b. N.	25 m.	NNW. ½W.	36
N. b. E.	40 m.	NE. b. E. ½E.	72 m.	SE.	50
ENE.	65 m.				

Required her preſent latitude and longitude, with her direct courſe a diſtance to the North Cape, in lat. 71° 27′ *N., longitude* 26° 30′ *E.?*

Courſes.	Diſ.	D. lat.		Depart.		Succeſſ. lats.	Mer. parts.	Mer. diff. lat.	Diff. lon	
		N.	S.	E.	W.				E.	W
						68° 38′	5733,7			
NE. b. N.	63	52,4		35,0		69 30	5879,2	145,5	97,2	
NE.	38	26,9		26,9		69 57	5957,2	78,0	78,0	
NNE.	56	51,7		21,4		70 49	6112,1	154,9	64,0	
North	30	30,0				71 19	6264,5	92,4		
NW. b. N.	25	20,7			13,9	71 40	6270,7	66,2		44
NNW. ½W.	36	31,7			17,0	72 12	6373,9	103,2		55
N. b. E.	40	39,2		07,8		72 51	6503,8	129,9	26,0	
NE. b. E. ½E.	72	33,9		63,5		73 25	6621,0	117,2	219,4	
SE.	50		35,3	35,3		72 50	6500,4	120,6	120,6	
ENE.	65	24.9		60,0		73 15	6586,1	85,7	207,0	
		311,4	35,3	249,9	30,9				812,2	99
		35,3		30,9					99.0	
Diff. latit.		276.1		210,0 Dep.				Diff. longit	713.2	

The diff. long. found by the middle latitudes is 712.

Depart. lat.	68° 38′ N.			Dep. long.	8° 40′
Diff. lat.	4 36 N.			Diff. long.	11 53
Preſent lat.	73 14 N.	Mer. parts	6582,6	Preſ. long.	20 33
N. Cape lat.	71 27 N.	Mer. parts	6229,6	N. Cape long.	26 30
Diff. lat.	1 47 N.	Mer. diff. lat.	353,0	Diff. long.	5 57
Or	107 miles.			Or	357 mi

By Middle latitude.

Sum lats. 144° 41′

Mid. lat. 72 21

Co-mid. lat. 17 39

With co-m. lat. and diff. long. find dep.
To diff. long. 300 the Dep. is 91,47
To diff. long. 57 Dep. is 17,38

To diff. long. 357 Dep. is 108,85

As the diff. lat. and dep. are ſo nearly equal, therefore
The Courſe is SE.
The Diſtance is 152 miles.

By Mercator.

With the mer. diff. lat. and t diff. long. the courſe will be fou 4 points, or SE.

And with the courſe and pro diff. lat. the departure will be 1 and the diſtance 152.

SECTIO

SECTION VI.

The conſtruction and uſe of a Mercator's Chart.

The linear and numeral ſolutions of ſuch queſtions as may be pro-
ed concerning ſailing by the principles on which Mercator's charts
founded, having been ſufficiently exemplified; it follows next to
w how ſuch queſtions may be ſolved by the Chart itſelf.

PROBLEM I.

*o make a true ſea chart which ſhall ſhew the known ſea-coaſts, iſlands,
s, ſhoals,* &c. *that are contained within any propoſed limits.*

SOLUTION.

ſt. Conſtruct the boundaries or limits of the chart, within the pro-
ed latitudes and longitudes, by Prop. IV. art. 725; and let the de-
s of latitude and longitude be marked on theſe limits.

d. On a piece of ſtiff paper, parchment, *&c.* make a ſcale of equal
s, like the degrees of longitude that are in the graduated parallel of
ude, and let the diviſions on this ſcale be numbered in the ſame
ner.

d. From a table of the latitudes and longitudes of places, extract
e places, with their latitudes and longitudes, that lie within the
oſed limits.

th. Then by ſliding the outſide diviſions of the ſcale of the gradu-
l parallel, along the graduated meridians, ſo that both ends of the
e, at the ſame time, always cut like diviſions of latitude; the points
eſponding to the latitudes and longitudes of the places contained
hin the propoſed limits, may be readily marked in the chart.

th. Lines being properly drawn from point to point, will form
outlines of the ſea-coaſts, iſlands, *&c.*; to which may be annexed
depths of water, *ſetting of currents*, and whatever elſe may be judged
venient for the chart to contain.

n this manner was conſtructed the ſea-coaſts, *&c.* in the chart in
e VII.; containing part of the ſea-coaſts of Europe, Africa and
erica, with the intermediate iſlands; extending from the latitude of
degrees to 59 degrees north; and from the longitude of London, or
grees, to 80 degrees of longitude weſt.

92. The Gunter's ſcales have drawn on them two lines, one marked
r., ſignifying the *nautical meridian*; and the other, which is placed
ctly under it, is marked *E. P.*, ſignifying *equal parts*.

heſe equal parts are degrees of longitude, to which the diviſions
he nautical meridian are fitted by increaſing them in their true pro-
ion; which is readily done by the table in art. 725, taking the me-
onal degrees from the ſcale of equal parts, or degrees of longitude.
e uſe of theſe two lines is to conſtruct a Mercator's chart by, and to
v nearly the meridional diff. lat. between any two parallels of lati-
tu.

The conſtruction of the chart, or rather the limits or borders ther of, by theſe lines, is eaſily done by transferring the diviſions cor ſponding to the degrees to be uſed, from the ſcale to the paper.

The meridional difference of latitude is found by taking with t compaſſes the extent between the propoſed latitudes, and applying it the line of longitude; for the number of equatorial degrees and parts degrees being reduced to miles, will ſhew the mer. diff. latitude betwe thoſe parallels.

It has been uſual on the Gunters hitherto made, to take ſo ſmall a p for a degree of longitude, that 180 of them came within the length two feet; and as about 85 meridional degrees anſwered to this lengt ſo many were put on the line; whereby the charts conſtructed fr them had their degrees rather too ſmall to be of much uſe to ſeame whoſe inſtruments and hands are not uſually ſo ſufficiently nice, as work by ſuch ſmall charts: Therefore it is apprehended, that it wou be more uſeful to increaſe the diviſions of theſe lines, and inſtead 180 degrees of longitude to put 100, and then about 70 meridional grees will come within the limits of two feet; navigations to hig latitudes being ſeldom undertaken. Gunter's ſcales with theſe, a other uſeful alterations, have been lately made by the direction of t author, and ſold by their makers.

793. PROBLEM II.

A latitude and longitude being given, to find the correſponding place the chart. Example. Lat. 32° 25′ N. long. 17° 21′ W. Plate VII.

SOLUTION.

1ſt. In the graduated meridian *, take, with a pair of compaſſes, t diſtance between the propoſed latitude and the neareſt parallel of la tude drawn acroſs the chart, as between the lat. 32° 25′, and the p rallel of 30°.

2d. With other compaſſes, take the diſtance in the graduated p rallel † between the propoſed longitude and the neareſt meridian dra acroſs the chart, as between the long. 17° 21′ W. and the meridi paſſing thro' 20° of longitude.

3d. Slide the point of one compaſs along the meridian of 20°, an point of the other compaſs along the parallel of 30°, keeping the poi of each compaſſes perpendicular to the line they ſlide along; then w the meeting of the other points of the compaſſes ſhew the place cor ſponding to the given latitude and longitude; which in this example the weſt end of the Iſland of Madeira.

This problem is moſt readily ſolved by the means of ſuch a movea ſcale of longitude, as is deſcribed and uſed in the foregoing Problem.

Or thus. A meridian drawn thro' the degrees of longitude give and a parallel of latitude drawn thro' the given degrees of latitude, th interſection will be the place required.

---

* The graduated meridian, is the ſcale of latitudes on the right or l hand borders of the chart.

† The graduated parallel, is the ſcale of longitudes on the top or bott borders of the chart.

4. PROBLEM III.

A place being given on the chart, to find its latitude and longitude.

Suppoſe Palma one of the Canary iſles. Plate VII.

SOLUTION.

rſt. With the compaſſes, take the ſhorteſt diſtance between the given ce and the neareſt parallel of latitude; this diſtance applied to the duated meridian, from the ſaid parallel the ſame way the place lies, l give the latitude ſought. Thus the diſtance from Palma to the pa- el of 30°, applied from 30° ſouthward, gives 28° 35′ N. for the la- de ſought.

d. In like manner, the ſhorteſt diſtance taken between the given e and the neareſt meridian, being applied to the graduated parallel, n that meridian, will give the longitude: Thus the diſtance from ma to the meridian thro' 20°, applied from 20° eaſtward, will give 41′ W. longitude.

PROBLEM IV.

wo places being given on a Mercator's chart, to find their difference of tude and difference of longitude.

Suppoſe Cape Finiſterre and the Iſland of Porto ſancto. Plate VII.

SOLUTION.

ind the latitude and longitude of each place; then the required dif- nces are readily known.

Prob. III.	C. Finiſterre's lat.	= 43° 15′N.	Long.	=	9° 20′ W.
	Iſl. Porto ſancto lat.	= 33 07 N.	Long.	=	15 53 W.
	Diff. lat.	= 10 08	D. long.	=	6 33 W.

PROBLEM V.

etween two given places on a Mercator's chart, to find the bearing or ſe.

uppoſe between Cape Clear and the Iſland St. Michael. Plate VII.

SOLUTION.

ay the edge of a ruler upon Cape Clear and the middle of the Iſland of St. Michael; and holding the ruler in this poſition, take with a pair of compaſſes the ſhorteſt diſtance between the edge of the ruler and the centre of the neareſt compaſs, or flie; ſlide one point along the edge of the ruler, till the other point cuts the border of the flie; and the ſe will be found to be SW. b. S. ¼ W. nearly.

nd the like for other places.

PROBLEM VI.

Two places being given in a Mercator's chart, to find their diſtance.

797. CASE I. *When the given places are both under the ſame meridia or under the equator.*

SOLUTION.

Find the latitude of each place when under the ſame meridian, their longitudes if under the equator.

Then the difference of the latitudes is the diſtance ſought; or, t difference of longitudes is the diſtance ſought.

798. CASE II. *When the given places are both under the ſame paral of latitude.*

Suppoſe between Cape Roxant and the Iſland of St. George. Pl. VI

SOLUTION.

Lay the edge of a ruler over the given places; take half the diſtan of thoſe places with the compaſſes; ſet one point on the diviſion c by the ruler in the graduated meridian, and apply the other point u wards and downwards on the ſame meridian, noting the degrees of l titude the ſaid point falls on: Then the difference of thoſe latitudes w be the diſtance ſought, very nearly.

Thus, half the diſtance between Cape Roxant and the Iſland of S George, will reach from 38° 45′, the diviſion cut by the edge of a rul laid over thoſe places, to 45° 00′ northward; and to 32° 20′ ſout ward; the difference between theſe two latitudes is 12° 40′, or 7 miles nearly, for the diſtance required.

But if the propoſed places lie in a parallel of latitude greater th 30 degrees, it will be nearer the truth to work as follows.

Take with the compaſſes that meridional degree wherein the para lel falls; and as many times as this diſtance is contained in a ſtrait li between the two places, of ſo many degrees is their diſtance to be eſt mated; which is reduced to miles as before.

Thus, the diſtance between the latitudes of 37° 30′ N. and 3 30′ N. will be contained between Cape Roxant and the Iſland of George about 12⅔ times; or 12° 40′, as before *.

799. CASE III. *When the given places differ both in latitude and lo gitude.*

Suppoſe the Lizard and the Iſland of Corvo. Plate VII. Fig. 4.

SOLUTION.

Find the latitudes of the two places, and their diff. latitude. Ta the diff. lat. in degrees and parts from the equator.

---

* Theſe operations depend on the following proportion.
As mer. diff. lat. : proper diff. lat. : : diff. long. : departure; which w differ but very little from the meridional diſtance, unleſs the places are ve far aſunder.

Lay the edge of a ruler over the two places; ſlide one point of the mpaſſes along the edge, till the other point, held perpendicular to the er, falls on a parallel of latitude, and take the length of the paral- intercepted between this point and the edge of the ruler.

Then this extent applied to the graduated parallel gives, in degrees, diſtance ſought.

Thus, the difference of latitude between Corvo and the Lizard is 0° 09′; then 10° 09′ taken from the graduated parallel, and one point the compaſſes applied to the edge of the ruler laid in the direction , ſlide that point along CL till the other point, kept in a perpendicu- poſition, cuts the parallel of 50° in B; then the diſtance BL, mea- ed on the graduated parallel, gives about 20° 25′ = 1225 miles, the tance required.

OR THUS. Take the difference of latitude 10° 09′ from the gradu- d parallel, apply one point of the compaſſes to the edge of the ruler ching C and L, ſlide this point along till the other point touches a allel (and not cutting it) in E; then the other point reſting at D, e the diſtance DL, which meaſured on the graduated parallel will give, degrees, the diſtance ſought.

Theſe methods are in effect the ſame; for the triangles LBA, LDE, congruous; as the angle at L is common, the angles A and E are ht angles, and the ſides AB, ED, are equal; therefore BL and DL are ual. (192)

f the difference of latitude DE be taken on a meridian thro' C, from o F; and the parallel of latitude FH be drawn, cutting the rhumb e CL in H; then are the triangles LDE, HCF, congruous; and CH = DL. (185, 192)

Now it is evident, that the parts of the triangles CFH, CGL, bear ſame proportion to one another, as have been ſhewn in art. 727; ere CF is the proper diff. lat., CG the merid. diff. lat., GL the diff. gitude, FH the departure, and CH the diſtance: Conſequently the ance DL, or BL, found as above, is the true diſtance ſought.

85. PROBLEM VII.

Given the latitude and longitude of the departed place, the courſe, and the itude of the preſent place: Required that place on the chart.

EXAMPLE.

A ſhip from the Iſland of Flores runs SE. b. S. ¾ E. till ſhe finds herſe in the latitude of 17° 29′ N.: Required her preſent place? Pl. VII. F. 5.

SOLUTION.

Thro' the departed place, Flores, draw the given rhumb, *viz.* SE. bS. ¾ E.; and its interſection with the parallel of latitude drawn thro' t latitude of the preſent place, *viz.* 17° 29′, will give the ſhip's place the chart; which will be near the Iſland of Ferro, or in lat. 27° 48′ N. lg. 17° 26′ W.

801. PROBLEM VIII.

Given the departed place, and alſo the courſe and diſtance, to find preſent place on the chart.

EXAMPLE.

A ſhip from the Iſland of Ferro runs NW. b. N. ¾ W. 951 mile What is the latitude and longitude of the preſent place? Plate VI Fig. 5.

SOLUTION.

Lay the edge of a ruler over Ferro in the poſition of the giv courſe NW. b. N. ¾ W.; take the degrees 15° 51′ in the given diſtanc 951 miles, from the graduated parallel, and apply this extent from Fer along the ruler's edge to R; take the neareſt diſtance between R, a a parallel PZ drawn thro' Ferro, and ſee how many degrees this exte makes on the graduated parallel, which will be 11° 35′; thoſe degre counted northwards from Ferro will give 39° 23′ N. for the ſhip's la tude; then the point Q, where a parallel thro' this latitude interſects t edge of the ruler, ſtill lying in the firſt poſition, will be the ſhip's pr ſent place.

802. *If the courſe be due eaſt or weſt.*

EXAMPLE.

A ſhip from Cape Roxant ſails due weſt 760 miles: Required her p ſent place. Pl. VII.

SOLUTION.

Take half the degrees (*viz.* 6° 20′) in the given diſtance, 760 mile add them to, and ſubtract them from, the given lat. 38° 42′, noti the ſum 45° 02′, and the remainder 32° 22′: Then the extent betwe thoſe degrees taken in the graduated meridian, and applied from t given place weſtward in the parallel, will give the ſhip's preſent plac which will be near the Iſland of St. George.

Or thus, if the latitude be above 30 degrees.

Take the length of a degree in the latitude of the given parallel, much above the parallel as below it; and turn this diſtance over in t parallel, the ſame way the courſe is, as many times as there are degr in the given diſtance, and this will give the ſhip's place.

Thus the length of a degree taken, in the latitude 38° 42′, a turned over from Cape Roxant to the weſt 12⅔ times, the compaſ will fall on the Iſland of St. George.

803. PROBLEM IX.

Given the departed place, with the difference of latitude and diſtan Required the ſhip's place on the chart.

EXAMPLE.

A ſhip from Q ſails in the SE. quarter 951 miles, and then fi herſelf in lat. 27° 48′ N., having altered her latitude 11° 35′: Requi her preſent place. Plate VII. Fig. 5.

SOLUTION.

Take from the graduated parallel the difference of latitude 11° 3 this extent from Q along the edge of a ruler, lying north and uth, to x; turn the edge of the ruler about x till it lies in an eaſt d weſt poſition: From the graduated parallel take 15° 51′, the de- es in 951 miles the given diſtance, apply this extent from Q to cut e edge of the ruler in v: Let the points of the compaſſes reſt in Q d v, and apply the edge of the ruler cloſe to thoſe points; then the int P, where the parallel of 27° 48′ is cut by the ruler's edge, is the p's place required.

Or, by drawing lines on the chart, let the diff. lat., taken from the duated parallel, be applied in a meridian drawn thro' Q from Q to From Q with the diſtance in degrees taken from the graduated pa- lel, cut, in v, a parallel drawn thro' x: Then the point P, where rhumb thro' Q and v cuts the parallel of latitude come to, *viz.* 27° ′, is the place ſought.

4.

PROBLEM X.

Given the departed place, with the courſe and difference of longitude: quired the ſhip's place on the chart.

EXAMPLE.

A ſhip from P ſails NW. b. N. ¾ W: Required her place when ſhe s altered her longitude 12° 53′? Plate VII. Fig. 5.

SOLUTION.

Take the given difference of longitude 12° 53′ from the graduated allel; ſlide one foot of the compaſſes along the edge of a ruler laid P, in the poſition PQ of the given courſe, until the other foot juſt iches in T a meridian PT drawn thro' P; then will the point Q, ere the foot reſts againſt the ruler's edge, be the place required.

805. *If the courſe had been due eaſt or weſt.*

EXAMPLE.

A ſhip from Cape Roxant ſails due weſt until ſhe has altered her lon- ude 16° 40′: Required her place on the chart.

SOLUTION.

Take the difference of longitude 16° 40′ from the graduated parallel; n this extent applied from the given place Cape Roxant due weſt, will e the place required, which is near the Iſland of St. George.

86.

PROBLEM XI.

Given the departed place, with the difference of latitude and departure: quired the ſhip's place on the chart.

EXAMPLE.

A ſhip from Q, in lat. 39° 23′ N., ſails between the ſouth and eaſt ſhe comes into the lat. 27° 48′ N., having made by account 649 les of departure: Required the ſhip's preſent place? Pl. VII. Fig. 5.

SOLUTION.

Take the given difference of latitude 11° 35′ from the graduated allel, and apply this extent from Q, along the edge of a ruler d in the meridian of Q, to x; take 10° 49′ = 649 miles, the given departure, from the graduated parallel; ſet one foot on x, lay this extent eaſtward to v, ſo that x v be in a perpendicular poſit to the ruler's edge: Lay the edge of the ruler on the points Q and and where it cuts ZP, the parallel of the ſhip's preſent latitude in P, the ſhip's place required.

Then the longitude, courſe and diſtance may be found as before. articles 794, 796, 799.

807. PROBLEM XII.

Given the departed place, with the courſe and departure: Required ſhip's place on the chart.

EXAMPLE.

A ſhip from P, in latitude 27° 48′ N., ſails NW. b. N. ¾ W., u ſhe has made 649 miles of departure: Required her preſent plac Pl.VII. Fig. 5.

SOLUTION.

Lay the edge of a ruler over the given place P, in the poſition of given courſe NW. b. N. ¾ W.; take from the graduated parallel 1 49′ = 649, the given departure, and ſlide one foot along the rul edge, until the other foot juſt touches in S a meridian PT drawn th P; the diſtance SP applied to the graduated parallel gives the diff. l tude; and conſequently the preſent latitude is known: Then where ruler's edge, lying in the ſame poſition, cuts the preſent parallel of TQ, as in Q, is the place ſought.

808. PROBLEM XIII.

Given the departed place, with the diſtance and departure, to find ſhip's preſent place on the chart.

EXAMPLE.

A ſhip from Q, in lat. 39° 23′ N., in ſailing between the ſouth a eaſt 951 miles, found ſhe has made 649 miles of departure: Where the preſent place of the ſhip? Plate VII. Fig. 5.

SOLUTION.

From the graduated parallel take 10° 49′ = 649 miles, the given parture, and lay this extent from Q to O directly eaſt; with the exte 15° 51′ = 951 miles, the given diſtance, taken from the graduated rallel, one foot being ſet in Q, with the other foot cut the edge o ruler laid on O in a meridional poſition, as in V; transfer the diſtan OV from Q to X in a meridian paſſing thro' Q; then QX meaſured the graduated parallel gives the diff. latitude, and conſequently the p ſent latitude 27° 48′ will be found: Lay a ruler's edge over Q a V, and where it cuts the parallel of 27° 48′, as in P, is the ſhip's pla required.

SECTION VII.

Of ſailing on a Great circle of the ſphere.

809. GREAT CIRCLE SAILING is the art of finding what places a h muſt go thro', and what courſes to ſteer, ſo that her tract ſhall be n the arc of a great circle (or nearly ſo) paſſing thro' the place ſailed m and that bound to.

Although Mercator's ſailing reſolves truly all the caſes incident to a h's courſe along the rhumb paſſing thro' two places; yet there are e caſes, wherein the courſe performed on the direct rhumb line is the rteſt diſtance between thoſe two places.

For on the ſphere, the ſhorteſt diſtance between two places is the of a great circle intercepted between them (404); conſequently the al or rhumb, paſſing thro' thoſe places, is not the ſhorteſt diſtance when that rhumb coincides with a great circle, which can only be meridian, or on the equator.

Now it is chiefly on account of the ſhorteſt diſtance that this method ſailing has been propoſed; and it is for the moſt part advantageous a ſhip to reach her port by the ſhorteſt way ſhe can, when and where practicable.

As the ſolutions of the caſes in Mercator's ſailing were performed by ne triangles; ſo the caſes in Great circle ſailing are reſolved by the tion of ſpheric triangles.

A great variety of caſes may be propoſed in this kind of ſailing; but they ſerve rather for exerciſes in the ſolution of ſpheric triangles, than any real uſe towards the navigating a ſhip, therefore thoſe apper- ing to only one problem will be here more particularly conſidered, they are the moſt uſeful caſes that uſually occur.

810. The angle of poſition, is an angle which a great circle, paſſing two places, makes with the meridian of one of them; and ſhews the angular poſition of one from the other.

PROBLEM.

Given the latitudes and longitudes of two places on the earth: Required the neareſt diſtance on the ſurface, together with the angles of poſition from either place to the other.

This problem may be branched into ſix caſes.

811. CASE I. *When the two places lie under the ſame meridian.*

SOLUTION. Their difference of latitude will give their diſtance; and the poſition of one from the other will be directly north or ſouth.

812.

812. Case II. *When the two places lie under the equator.*

Solution. Their diſtance is equal to their difference of longitud and the angle of poſition is a right angle, or the courſe from one to t other is due eaſt or weſt.

813. Case III. *When both places are in the ſame parallel of titude.*

Example. *What is the leaſt diſtance between St. Maries, in latit 37° 00′ N., longitude 22° 56′ W., and Cape Henry, in latitude 37° 0 longitude 76° 23′ W.?*

General Construction. Plate VIII. Fig. 25.

1ſt. Deſcribe a circle PESQ repreſenting the meridian of one of t places, ſuppoſe of the eaſtern one, as St. Maries; draw the line EQ preſenting the equator, and at right angles to it draw the line PS for t axis of the earth, whoſe extremity P is the north pole, and S is the ſou pole; and on this circle lay off from P to A the complement of t latitude of (St. Maries) the eaſtern place.

2d. On the equator, lay off from Q to C (446) the difference of lo gitude between the two places (53° 27′); and thro' P, C, S, (163) ſcribe the circle PCS, which will be the meridian of the other pla (Cape Henry); on which lay from P to B the co-latitude of this plac which is done by deſcribing the arc A *a* about the pole P (456) at t diſtance of the co-latitude.

3d. Thro' the points A, B, D, deſcribe a great circle ABD. (16

Then A repreſents one place (St. Maries), B the other (Cape Henry PA and PB are their co-latitudes; the angle APB, which is meaſu by the arc QC (389), is the diff. long. the arc AB is the neareſt diſtan of thoſe places; the angle PAB is the angle of poſition from A to and the angle PBA is the angle of poſition from B to A.

The arc AB may be meaſured as directed in article 446.

And the angle PAB, or PBA, as ſhewn in art. 448.

Now the places having the ſame latitude; therefore $PA = PB$, a $\angle PAB = \angle PBA$ (470). Therefore, if the arc PI be deſcribed (45 making the angle $API = 26° 43\frac{1}{2}'$, the half of the difference of lon tude; then will PI be perpendicular to AB, biſecting it.

And in the triangle AIP, right-angled at I, there will be given t hypothenuſe $AP = 53° 00'$; the $\angle API = 26° 43\frac{1}{2}'$; to find the leg = half the diſtance ſought, and the $\angle PAI$ = the angle of poſition.

And the ſolution hereof falls under art. 513, 515.

To find the diſtance.

Radius	Or, As Rad	=	90°	00′	10,00000
ſin. hyp. PA,	To ſin. co-lat.	=	37	00	9,90235
ſin. giv. ∠ API	So ſin. ½ diff. long.	=	26	43½	9,65292
ſin. leg AI.	To ſin. ½ diſtance	=	21	03	9,55527

Which doubled, gives 42 06 for the diſt. AB.

d this 42° 06′ reduced to nautical miles, is 2526, which is 35 miles than 2561, the diſtance given by parallel ſailing. See art. 755.

To find the angle of poſition. (515)

Radius	Or, As Rad	=	90°	00′	10,00000
coſ. hypoth. PA,	To ſin. lat *	=	37	00	9,77946
tan. giv. ∠ API	So tan. ½ diff. lon.	=	26	43½	9,70199
cot. ∠ A.	To cot. ∠ poſit.	=	73	09	9,48145

Vhereby it appears, that to ſail from A to B, or from B to A, the muſt firſt ſteer N. 73° 09′ W. or E.; and then gradually increaſe courſe till ſhe comes to I, where it will be due W. or E.; and from ice the courſe is to be gradually diminiſhed again till ſhe comes to other port, where it will be 73° 09′, the ſame as ſhe ſet out with: how theſe courſes are to be thus altered, will be ſhewn hereafter.

. CASE IV. *When one place has latitude, and the other has none, or is under the equator.*

XAMPLE. *What is the neareſt diſtance between the Iſland of St. Thomas, in lat.* 0° 00′, *and long.* 1° 00′ *E., and Port St. Julian, in lat.* 48° *S., and longitude* 65° 10′ *W.?*

Port St. Julian, in lat.	48° 51′ S.	Long.	65° 10′ W.
Iſl. St. Thomas, in lat.	0 00	Long.	1 00 E.
Julian's co lat.	41 09	Diff. long.	66 10

BY CONSTRUCTION. Plate VIII. Fig. 26.

et the point A be St. Thomas under the equator, whoſe poles are nd S.

ake AC, the meaſure of the angle ASC, equal to 66° 10′ = diff. on. (450)

hen as Port St. Julian is in ſouth lat., about S the ſouth pole, at the ance of Julian's co-lat., deſcribe the arc *a a*, cutting SCP, the meian of Julian, in B. (454)

hro' the points A, B, E, a great circle being deſcribed, then the arc is the diſtance ſought. (163)

he diſtance AB may be meaſured by art. 446.

nd the angles of poſition at A and B are to be meaſured as directed rt. 448.

For the complement of a complement, is the arc itſelf: Thus QA, or the ance from the equator, ſhews the lat. But QA is the comp. of AP; and AP of Q.

Computation. In the quadrantal triangle ASB, there is
Given the co-lat. of St. Thomas, or AS = 90° 00′ } The reſt :
the co-lat. of St. Julian, SB = 41 09 } found as in a
the diff. longitude, ∠ASB = 66 10 } 545.

Or, in the ſupplemental triangle ACB, right angled at C, there is
Given the lat. of St. Julian's, or the leg CB = 48° 51′.
the difference longitude, or the leg CA = 66 10.

The ſolution falls under article 523.

To find the diſtance AB.

As Radius	Or, As Radius =	90°	00′	10,000
To coſ. either leg,	To coſ. diff. long. AC =	66	10	9,606
So coſ. other leg	So coſ. diff. lat. CB =	48	51	9,818
To coſ. hyp.	To coſ. diſt. AB =	74	35	9,424

So that the diſt. AB = 74° 35′ is 4475 miles; which is leſs by miles than the diſtance found by Mercator's ſailing.

To find the angle of poſition at A. (522)

As Radius	Or, As Radius =	90°	00′	10,000
To ſin. leg AC,	To ſin. diff. long. AC =	66	10	9,961
So cot. leg CB	So cot. diff. lat. CB =	48	51	9,941
To cot. op. ∠A.	To cot. ∠ poſit. at A =	51	22	9,902

To find the angle of poſition at B. (522)

As Radius	Or, As Radius =	90°	00′	10,000
To ſin. leg CB,	To ſin. diff. lat. CB =	48	51	9,876
So cot. leg AC	So cot. diff long. AC =	66	10	9,645
To cot. op. ∠B.	To cot. ∠ poſit. at B =	71	36	9,521

So that a ſhip ſailing from the Iſland of St. Thomas muſt firſt ſha her courſe S. 51° 22′ W.; and then by conſtantly altering her cou towards the weſt, ſo as to arrive at Port St. Julian on a courſe S. 7 36′ W., ſhe will have ſailed the ſhorteſt diſtance between thoſe places.

815. Case V. *When the latitudes of the given places are b north or both ſouth.*

Example. *What is the neareſt diſtance between the Lizard and the land of Bermudas; and alſo the angles of poſition at each place?*

The Lizard in lat.	49°	57′ N.	and long.	5°	14′ W.
Iſl. Bermudas in lat.	32	25 N.	and long.	66	38 W.
			Diff. long.	61	24

By Construction. Plate VIII. Fig. 27.

Make PA = 57° 35′, the co-lat. of Bermudas; P*a* = 40° 03′, t co-lat. of the Lizard; and (456) with the tang. of P*a* deſcribe the arc *a*

Wi

Vith the ſecant of 61° 24′, the diff. long. (452), arcs deſcribed from
nd S, give the centre of the circle PCS, the meridian of the Lizard;
interſection with *a a* gives B, the place of the Lizard.
great circle deſcribed thro' A, B, D (163); the intercepted arc AB
e diſtance ſought; and the angles PAB, PBA, are the poſitions re-
ed.

he diſtance AB may be meaſured by art. 446; and the poſitions by
r 448.

ad the eaſtern place, the Lizard, been put on the primitive circle,
great circle AB would have been difficult to deſcribe; and therefore
the weſtern place put on the primitive circle; it being a matter of
fference which of the places are ſo taken.

OMPUTATION. In the oblique ſpheric triangle APB.

iven Bermudas's co-lat., PA = 57° 35′
Lizard's co-lat., PB = 40 03
Diff. longitude, ∠APB = 61 24
} Required the reſt.

he ſolution falls under art. 534.

To find the diſtance AB.

adius	Or, As Radius	=	90° 00′	10,00000
of. giv. ∠,	To coſ. diff. long. ∠APB	=	61 24	9,68006
in. eith. ſide	So tan. Berm. co-lat. PA	=	57 35	10,19721
an. M.	To tang. fourth arc	=	37 01	9,87727
	Which take from Liz. co-lat.	=	40 03	
	Leaves a fifth arc	=	3 02 = N.	
of. M	As coſ. fourth arc	=	37 01	0,09775
of. N,	To coſ. fifth arc	=	3 02	9,99939
of. ſide 1ſt uſed	So ſin. Bermudas lat.	=	32 25	9,72922
of. ſide required.	To coſ. diſtance AB	=	47 54	9,82636

To find the angle of poſition PBA. (533)

s this angle is oppoſite to the ſide uſed in the firſt proportion,
efore the fourth and fifth arcs here uſed, are the ſame as above.

in. N	As ſin. fifth arc	=	3° 02′	1,27641
in. M,	To ſin. fourth arc	=	37 01	9,77963
n. given ∠	So tan. diff. long. ∠APB	=	61 24	10,26343
an. req. ∠	To tan. ∠ poſit. ∠PBA	=	87 15	11,31947

To find the angle of poſition PAB.

he other parts being found, this angle may be found by the pro-
on between oppoſite ſides and angles. Thus:

n. PA	Or, As ſin. Bermudas's co-lat.	=	57° 35′	0,07357
in. ∠PBA,	To ſin. ∠ poſ. at Lizard	=	87 15	9,99950
n. PB	So ſin. Lizard's co-lat.	=	40 03	9,80852
in. ∠PAB.	To ſin. ∠ poſ. at Bermudas	=	49 35	9,88159

Or, working by art. 533, the ſame angle would be obtained.

Alſo, Had the two firſt proportions been worked with the Lizard's titude inſtead of Bermudas's, the ſame diſtance would have been fou

So the ſhorteſt diſtance between the Lizard and Bermudas is 47° 5 or 2874 ſea miles; which is 178 miles leſs than the diſtance found Mercator's ſailing.

And a ſhip to run this ſhorteſt tract, muſt ſail from the Lizard 87° 15′ W., and gradually to leſſen the courſe, ſo as to arrive at B mudas on the rhumb bearing S. 49° 35′ W.; Whereas the direct cou from one place to the other, as found by Mercator's ſailing, is S. 69° 02′

816. Case VI. *When one of the given places has north latitude the other has ſouth latitude.*

Example. *What is the neareſt diſtance from the Iſland of St. Hel to the Iſland of Bermudas; and alſo the angles of poſition at each place?*

Iſland of Bermudas in lat.	32° 25′ N.	and long.	66° 38′ W.
Iſland of St. Helena in lat.	16 00 S.	and long.	6 15 W.
		Diff. long.	60 23

By Construction. Plate VIII. Fig. 28.

Make QA = 16° 00′, the lat. of St. Helena; deſcribe the arc *a a* ab P (456) with the tangent of P *a* = 57° 35′, the co-lat. of Bermuda Arcs deſcribed from P, S, with the ſecant of 60° 23′, the diff. lon will give the centre of the circle PCS, the meridian of Bermudas; a its interſection B with *a a* is the place of Bermudas.

Deſcribe a great circle thro' A, B, D; the intercepted arc AB is t diſtance ſought, which may be meaſured by 446: and the angles PA ABS, are the poſitions required, which are to be meaſured as directed art. 448.

Computation. In the oblique ſpheric triangle ABP.

Given PA = 106° 00′, St. Helena's lat., added to 90°; or its N. pol. di

PB = 57 35, Bermudas's co-lat.

∠APB = 60 23, their difference of longitude.

To find the reſt. The ſolution falls under art. 533, 534.

To find the diſtance AB.

As Radius	Or,	As Radius	=	90° 00′	10,000
To coſ. ∠P,		To coſ. diff. long.	=	60 23	9,693
So tang. PB		So tan. Berm. co-lat.	=	57 35	10,197
To tang. M.		To tang. fourth arc	=	37 54	9,891
		Which taken from	=	106 00 = St. Helena's [polar di	
		Leaves a fifth arc	=	68 06 = N.	
As coſ. M	Or,	As coſ. fourth arc	=	37 54	0,102
To coſ. N,		To coſ. fifth arc	=	68 06	9,571
So coſ. PB		So ſin. Bermudas lat.	=	57 35	9,729
To coſ. AB,		To coſ. diſtance	=	75 19	9,403

To find the angle of poſition PAB.

The fourth and fifth arcs being found as before.

ſin. N	Or, As ſin. fifth arc	=	68°	06′	0,03253
ſin. M,	To ſin. fourth arc	=	37	54	9,78837
tan. ∠P	So tang. diff. long.	=	60	23	10,24530
tan. ∠A.	To tang. ∠ poſition	=	49	20	10,06620

To find the angle of poſition ABP.

Rad	Or, As Radius	=	90°	00′	10,00000
coſ. ∠P,	To coſ. diff. long.	=	60	23	9,69390
tan. PA	So tan. Helena's N. pol. diſt.	=	106	00	10,54250
tan. M.	To tang. fourth arc	=	59	53	10,23640

But by the determination, art. 533, this fourth arc is to be like PA, obtuſe; therefore the ſupplement of 59° 53′, or 120° 07′, is to be fourth arc: Then the difference between this fourth arc and PB, is ° 32′ for N, or the fifth arc. And

ſin. N	Or, As ſin. fifth arc	=	62°	32′	0,05194
ſin. M,	To ſin. fourth arc	=	120	07	9,93702
tan. ∠P	So tang. diff. long.	=	60	23	10,24530
tan. ∠ABP.	To tang. ∠ poſition	=	59	45	10,23426

But by the determination, art. 533, the ∠ABP is to be obtuſe, and therefore 120° 15′, which is the ſupplement of 59° 45′.

So that was a ſhip to ſail from St. Helena to Bermudas on the arc of a at circle, ſhe muſt firſt ſhape her courſe N. 49° 20′ W., and gradu- y deflect from the north, ſo as to arrive at Bermudas on a courſe N. ° 45′ W., after having run 75° 19′, or 4519 ſea miles.

The courſe found by Mercator's ſailing is N. 50° 05′ W., and the ance is 4527 miles.

Whereby it appears, that when the places are one in N. latitude, the other in S. latitude, there is but a ſmall difference between reſults found by Mercator's and circle ſailing: For near the equa- , the rhumb lines do not greatly differ from great circles.

From the ſolutions of the foregoing caſes it is plain, that to ſail on arc of a great circle, the ſhip muſt continually alter her courſe; t as this is a difficulty too great to be admitted into the practice of vigation, therefore it has been thought ſufficiently exact to effect this ineſs by a kind of approximation; that is, by a method which nearly roaches the ſailing on a great circle.

817. The principle upon which this approximation is founded, i *that in ſmall arcs, the difference between the arc and its chord, or tangen is ſo ſmall, that they may be taken one for the other in any nautical oper tions.*

Upon this principle, the great circles on the earth are ſuppoſed to l made up of ſhort right lines, each of which is a ſegment of a rhum line.

And on this ſuppoſition, the ſolution to the following Problem is d duced.

PROBLEM II.

818. *Having given the latitudes and longitudes of the places ſailed fro and bound to: To find the ſucceſſive latitudes on the arc of a great circle thoſe places where the alteration in longitude ſhall be a given quantity; t gether with the courſes and diſtances between thoſe places.*

SOLUTION.

I. Find the angle of poſition at each place, and their diſtance b one of the preceding ſix caſes.

II. Find the greateſt latitude the great circle runs thro'; that i find the perpendicular from the pole to that circle; and alſo fin the ſeveral angles at the pole, made by the given alteratior of longitude between this perpendicular and the ſucceſſive me ridians come to.

III. With this perpendicular and the polar angles ſeverally find many correſponding latitudes, by ſaying (521):
As Rad : tan. greateſt lat. : : coſ. 1ſt polar ∠ : tan. 1ſt lat.
: : coſ. 2d polar ∠ : tan. 2d lat.
&c. &c.

IV. Having the ſeveral latitudes paſſed thro', and the difference longitude between each, find by Mercator's ſailing (770), th courſes and diſtances between thoſe latitudes.

And theſe are the ſeveral courſes and diſtances the ſhip muſt run, t keep nearly on the arc of a great circle.

Now the ſmaller the alterations in longitude are taken, the nearer wi this method approach the truth: But the uſual way is to compute t every 5 degrees of difference of longitude; the length of an arc of 5 de grees differing from its chord or tangent only by 0,0002; as may b found from the articles 320, 326, 328.

The examples to the third, fifth, and ſixth of the preceding caſes ar hereafter reſolved by this method, whereby the difference between th length of the great circular arc paſſing thro' the two places, and th ſum of the ſeveral rhumbs ſailed on between thoſe places, may be com pared.

819. Question I. *A ſhip being bound from the Iſland of St. Maries t Cape Henry, propoſes to ſail as near the arc of a great circle as ſhe ca, by altering her courſe at every 5 degrees difference of longitude: Reqred the latitude at each time of altering the courſe, and alſo the courſes ad diſtances between thoſe ſeveral latitudes?*

St. Maries lat. is	37° 00′ N.	the long.	22° 56′ W.
Cape Henry's lat. is	37 00 N.	the long.	76 23 W.
		The diff. long.	53 27

The figure being deſcribed, and the computation made as in art. 813, t diſtance BA is found to be 42° 06′, and the ∠A or ∠B = 73° 09′, t angle of poſition. Plate VIII. Fig. 29.

Now the triangle APB being iſoſceles, the perpendicular PI falls in the ddle of AB; and the latitudes, courſes and diſtances being known in ning the half BI, thoſe in the half IA will alſo be known.

Let the points *a*, *b*, *c*, *d*, &c. be the places come to on each alteration of 5 degrees of longitude: then will the arcs P*a*, P*b*, P*c*, P*d*, &c. b the reſpective co-latitudes of thoſe places, and are the hypothenuſes the right-angled ſpheric triangles PI*a*, PI*b*, PI*c*, PI*d*, &c.

In the triangle PIB.
ven PB = 53° 00′
∠PBI = 73 09
T find PI. Art. 513.

As Rad	=	90° 00′	10,00000
To ſin. PI	=	53 00	9,90235
So ſin. ∠B	=	73 09	9,98094
To ſin. PI	=	49 51	9,88329

Nw ∠IPB $=\left(\frac{53^\circ\ 27'}{2}=\right)$ 26° 43½′; ∠IP*a* = 21° 43½′; ∠IP*b* = 16° 43½′; ∠IP*c* = 11° 43½′; ∠IP*d* = 6° 43½′; are the ſeveral polar angles.

		21° 43½′	16° 43½′	11° 43½′	6° 43½′
Ten (521) Rad	= 90° 00′	10,00000	10,00000	10,00000	10,00000
T cot. PI	= 49 51	9,92612	9,92612	9,92612	9,92612
S cof. polar angle		9,96800	9,98123	9,99084	9,99700
T tang. lat.		9,89412	9,90735	9,91696	9,92313
Which are		38° 05′	38° 56′	39° 33′	39° 57′

The degrees and min. ſet over each column, are the polar angles uſed in hat proportion, and the correſponding latitudes ſtand at bottom.

20. The firſt term of theſe proportions being radius, and the ſecond ten conſtant, the operations may be very expeditiouſly performed thus. n a ſlip of paper let the log. of the 2d, or conſtant term be wrote, o he ſame ſize with the printed figures; apply this log. cot. ſucceſſively t the log. coſines of the polar angles: Then the ſum of the two logs. bng wrote down each time, will give the log. tangents of the ſeveral laudes arrived at.

y this method, each proportion will be worked by writing down oy one line.

Hence it appears, the ſhip muſt firſt ſail from the lat. 37° 00′ N. lat. 38° 05′ N.; thence to lat. 38° 56′ N.; thence to lat. 39° 33′: then to lat. 39° 57′ N.; thence to lat. 40° 09′ N., which is the greateſt l titude ſhe muſt go to; and from thence ſhe muſt proceed thro' the l titudes 39° 57′, 39° 33′, 38° 56′, 38° 05′, and ſo to 37° 00′, the p rallel ſhe ſet out from, and wherein ſhe is to find Cape Henry.

Now between theſe ſeveral latitudes, with the reſpective differen of longitude, find by Mercator's ſailing, art. 770, the courſes and ſtances.

If the reſults of the ſeveral operations, in the queſtions of great cir ſailing, be entered in ſuch a table as the following, it will be found ſome convenience to the operator.

Polar angles		Succeſſ longs.	Succeſſ. lats.	Diff. long.	Diff lat.	Merid. parts.	Mer. diff. lat.	Cour.	Diſt.
∠IPB	26° $43\frac{1}{2}'$	22° 56′	37° 00′	300	65	2392,6	82,0	74,43	246,
∠IP*a*	21 $43\frac{1}{2}$	27 56	38 05	300	51	2474,6	65,2	77,44	240,
∠IP*b*	16 $43\frac{1}{2}$	32 56	38 56	300	37	2539,8	47,8	80,57	235,
∠IP*c*	11 $43\frac{1}{2}$	37 56	39 33	300	24	2587,6	31,2	84,04	232,
∠IP*d*	6 $43\frac{1}{2}$	42 56	39 57	403,5	12	2618,8	15,7	87,46	307,
		49 $39\frac{1}{2}$	40 09			2634,5			1261.

In the firſt column are the angles at the pole contained between t perpend. and the ſeveral meridians differing by 5° of longitude.

In the 2d col., the departed longitude 22° 56′ being increaſed by t differences of longitude, make the ſucceſſive longitudes come to.

In the 3d col. are the ſucceſſive latitudes paſſed thro', from St. Mari to the greateſt latitude.

In the 4th and 5th columns, are the differences between the longitud and latitudes in the 2d and 3d columns.

In the 6th column are the merid. parts to the ſucceſſive latitudes and in the 7th col. are the merid. diff. latitudes.

The 8th and 9th columns contain the courſes and diſtances betwe the places anſwering to the 2d and 3d columns.

The numbers in the 3d, 8th and 9th columns, are found by workir of the logarithmic proportions on a waſt paper; but the work is he omitted, as it is ſo eaſily ſupplied.

Now the column of diſtances being ſummed up, amounts to 1261,9 which being doubled gives 2523,8 miles for the diſtance between S Maries and Cape Henry; differing from the diſtance found (813) in great circle by 2,2 ſea miles.

And the courſes the ſhip muſt ſteer are, 1ſt. N. 74° 43′ W. 2d. N. 77° 44′ W.; 3d. N. 80° 57′ W. 4th. N. 84° 04′ W. 5th. N. 8 46′ W. 6th. S. 87° 46′ W.; 7th. S. 84° 04′ W.; 8th. S. 80° 57′ W. 9th. S. 77° 44′ W.; 10th. S. 74° 43′ W.: And on theſe courſes ſ muſt run the reſpective diſtances ſtanding againſt them.

82

821. QUESTION II. *A ſhip bound from the Lizard to the Iſland of rmudas, propoſes to ſail on a great circle, and to alter her courſe at every f degrees of longitude: Required the latitudes thro' which the ſhip is to pſs, and alſo the courſe and diſtance between each?*

The Lizard's lat. is 49° 57′ N. Long. 5° 14′ W. } Diff. long. 61° 24′.
Bermudas lat. is 32 25 N. Long. 66 38 W. }

Having deſcribed the figure, Plate VIII. Fig. 30, and found the ∠PAB = 49° 35′, the ∠PBA = 87° 15′, and the ſide AB = 47° 54′, as in a. 815.

Draw PI at right angles to ABD. (449)

n the equator, lay off from the centre the tangents of 5, 10, 15, 20 &. to 55 degrees; and thoſe points give the centres to the arcs of co- to every 5° diff. longitude. (451)

To find the perpend. PI. (513)

A Rad	= 90° 00′	10,00000
T ſin. PA	= 57 35	9,92643
S ſin. ∠A	= 49 35	9,88158
T ſin. PI	= 40 00	9,80801

To find the polar angle API. (515)

As Rad	= 90° 00′	10,00000
To tang. ∠A	= 49 35	10,06978
So cof. AP	= 32 25	9,72922
To cot. ∠API	= 57 48	9,79900

Now the polar angle API, or the diff. long. between the perpend. and the meridian of Bermudas, 57° 48′, being taken from 61° 24′, th whole diff. long., leaves the diff. long. between the Lizard and I: A 5°, the propoſed alteration of longitude, being ſubtracted as often as can be from 57° 48′, leaves the ſeveral polar angles; with which, a the perpendicular PI, the ſeveral latitudes arrived at are found by a 820.

Then having thoſe latitudes, and the differences of longitude between n, find the ſucceſſive courſes and diſtances by art. 770.

Let the ſeveral reſults be placed as in the following table; the lo- thmic work being performed on a waſt paper, is here omitted.

Alſo, ſuppoſe the ſmall letters in the figure ſupplied.

Polar angles			Succeſſ. longs.	Succeſſ. lats.	Diff. long.	Diff. lats.	Merid. parts.	Merid. diff. lat.	Courſe.	Diſts.
			5° 14′	49° 57′			3469,8			
IPB	3°	36′	8 50	50 00	216	3	3474,5	4,7	88° 45′	137,5
IP*a*	2	48	11 38	49 58	168	2	3471,4	3,1	88 56	107,4
IP*b*	7	48	16 38	49 44	300	14	3449,7	21,7	85 52	194,2
IP*c*	12	48	21 38	49 17	300	27	3408,1	41,6	82 06	196,4
IP*d*	17	48	26 38	48 37	300	40	3347,2	60,9	78 31	200,6
IP*e*	22	48	31 38	47 42	300	55	3264,7	82,5	74 37	207,3
IP*f*	27	48	36 38	46 31	300	71	3160,4	104,3	70 50	216,3
IP*g*	32	48	41 38	45 03	300	88	3034,2	126,2	67 10	226,8
IP*h*	37	48	46 38	43 17	300	106	2886,4	147,8	63 46	239,8
IP*i*	42	48	51 38	41 10	300	127	2714,9	171,5	60 15	255,9
IP*k*	47	48	56 38	38 41	300	149	2520,5	194,4	57 03	273,9
IP*l*	52	48	61 38	35 46	300	175	2300,7	219,8	53 46	290,1
			66 38	32 25	300	201	2058,0	242,7	51 02	319,6
										2871,8

Now the ſum of the ſeveral diſtances make 2871,8 miles.
But the diſtance in the arc of a great circle is 2874 miles. (8
The difference of the two methods is 2,2 miles.

In this example it was judged neceſſary to keep the fractional pl in the meridional parts, in order to have the diſtances more accurate

822. Question III. *A ſhip being bound from the Iſland of St. He. to the Iſland of Bermudas, it is propoſed ſhe ſhould ſail near the arc o great circle paſſing thro' thoſe places, and to alter her courſe at every 5 longitude: Required the latitudes where thoſe courſes are altered, and the courſe and diſtance between each place of alteration?*

St. Helena's lat. = 16° 00′ S. Long. 6° 15′ W. } Diff. lon. = 60°
Bermudas's lat = 32 25 N. Long 66 38 W. }

Having deſcribed the figure, Plate VIII. Fig. 31, and found the ∠I = 120° 15′; ∠PAB = 49° 20′; and the diſt. AB = 75° 19′; as art. 816.

In the equator QF, lay off from F the tangents of 5°, 10°, 15°, to 55°; and thoſe points will give the centres to the meridians paſ thro' every 5 degrees of long. between St. Helena and Bermudas. (4

To find the perpend. PI. (513)

As Rad	=	90° 00′	10,00000
To ſin. PB	=	57 35	9,92643
So ſin. ∠PBI	=	59 45	9,93643
To ſin. PI	=	46 49	9,86286

To find the polar ∠BPI. (515

As Rad	=	90° 00′	10,00
To coſ. BP	=	57 35	9,72
So tan. ∠PBI	=	59 45	10,23
To cot: ∠BPI	=	47 25	9,96

Now the ſeveral polar angles, longitudes, latitudes, diff. longs., lats., mer. parts, mer. diff. lats., courſes and diſtances being comp on a waſt paper, their reſults are to be entered in a table as follow:

Polar angles	Succeſſ longs	Succeſſ lats.	Diff. ong.	Diff. lats.	Merid. parts	Merid. d. lat.	Courſes	D
	6° 15′	16° 00′ S			973			
∠IP*l* = 102° 48′	11 15	11 45	300	255	709	264	48° 39′	38
∠IP*k* = 97 48	16 15	7 16	300	269	437	272	47 48	40
∠IP*i* = 92 48	21 15	2 38	300	278	158	279	47 05	40
∠IP*b* = 87 48	26 15	2 04 N	300	282	124	282	46 46	41
∠IP*g* = 82 48	31 15	6 43	300	279	404	280	46 58	40
∠IP*f* = 77 48	36 15	11 13	300	270	677	273	47 42	40
∠IP*e* = 72 48	41 15	15 31	300	258	943	266	48 26	38
∠IP*d* = 67 48	46 15	19 32	300	241	1195	252	49 58	37
∠IP*c* = 62 48	51 15	23 13	300	221	1433	238	51 34	35
∠IP*h* = 57 48	56 15	26 34	300	201	1654	221	53 37	33
∠IP*a* = 52 48	61 15	29 34	300	180	1858	204	55 47	32
	66 38	32 25	323	171	2058	200	58 14	32
								51

823. The track of a ſhip when directed nearly in the arc of a great cle, as in the preceding articles, may be delineated on the Mercator's cart, by marking thereon, by the help of the latitudes and longitudes, t ſucceſſive places where the ſhip is to alter her courſe; then thoſe pces or points being joined by right lines, will ſhew the path along hich the ſhip is to ſail under the propoſed circumſtances.

Thus in Plate VII is drawn the route propoſed in Queſtion II, art. 821, fm the Lizard to Bermudas: And notwithſtanding that this track on t chart appears much longer than the rhumb paſſing thro' thoſe two pces, yet it muſt be remembered, that theſe lines are only the repreſtations of curves on the ſphere whoſe abſolute lengths are not hereby preſſed.

SCHOLIUM.

824. The reaſoning and concluſions, in the preceding ſections of this ok, have been delivered as if the earth was a perfect ſphere: But thin the laſt 80 years it has appeared from many obſervations that its ure is not ſtrictly ſo, being rather like a figure altered from a ſphere, being a little flatted at the poles, ſomewhat of the ſhape of a flat nip or bowling-green bowl; or, in the language of mathematicians, *figure of the earth is an oblate ſpheroid, whoſe axis or polar diameter ſhorter than the equatorial diameter.* The proportion of theſe diameters cording to Sir Iſaac Newton, who firſt diſcovered it, is as 229 to 0; or, according to ſome later obſervations, as 230 to 231. Now s the difference between theſe diameters more conſiderable, it would atly affect all nautical concluſions deduced from a ſphere, and the ſent tables of meridional parts would be very imperfect: But by the le difference of the diameters the error is ſcarce ſenſible in ſeveral days rks, even in the higheſt latitudes where any conſiderable navigation carried on, and where the error would be greateſt. However, in der to put it in the power of thoſe who are inclined to adapt their opeions to the true figure of the earth, it will here be ſhewn how the tas of ſpheric meridional parts may be fitted to the ſpheroid.

The reader is deſired to excuſe the omiſſion of the computations upwhich the correcting of the meridional parts is founded; becauſe they pend on certain elements which were thought improper to be introced into a work of this kind: But thoſe who are qualified to undernd ſuch computations, may find them in ſeveral books, particularly in ac-laurin's fluxions, art. 896, and in Simpſon's fluxions, art. 465. heſe gentlemen have in a very elegant manner deduced the ſame neral rules for finding the meridional parts in a ſpheroid; but Mr. npſon having, from ſome farther conſiderations, fitted his rules more nveniently for practice, *his* corrections will herein be uſed.

825. *To find the correction for changing a table of ſpheric meridional rts to ſpheroidal meridional parts.*

RULE.

Say, As Radius is to the ſine of any given latitude,
So is the conſtant number 30 to the correction ſought.

Subtract the correction from the ſpheric meridional parts to the l tude uſed, and the remainder is the ſpheroidal meridional parts to t latitude.

Example. *Required the ſpheroidal meridional parts for the latitud 60 degrees?*

As Radius	10,00000	From ſpheric mer. parts to 60° 00′	452
To ſ. lat. 60° 00′	9,93753	Take the correction	2
So number 30	1,47712		
		Leaves ſpheroidal mer. pts. to 60° 00′	450
To cor. 25,98	1,41465		

Or, the correction may be readily found by the Traverſe table.

With the latitude 60°. among the courſes, and againſt 30 in the c lumn of diſtances, take in the column of departure the correction 26.

826. *To find the correction, for reducing any given parallel of latitude the ſphere to that of the ſpheroid.*

Rule.

Say, As Radius is to the ſine of double the given latitude,

So is the conſtant number 11,2 to the correction ſought; which ſubtracted from the minutes in the given latitude, reduces th parallel from the ſphere to the ſpheroid.

Or, *By the Traverſe table.*

Among the courſes, ſeek the double of the given latitude when und 45°, or the double of the co-latitude when above 45°, and againſt 11 i the col. of diſtances take the correſponding depart., which increaſed by fifth part of the diff. between that and the next greater will be the co rection ſought.

Exam. I. *Find the diſtance between the equator and the parallel of 2 on the ſpheroid.*

Under 40° (the double of 20°) and againſt 11 in the col. of di ſtands 7,1 in the col. of dep.; the difference between it and the ne greater, 7,7, is 0,6; a fifth part, or 0,1, added to 7,1 gives 7,2, t correction ſought.

Now 20° × 60 = 1200 min. Then 1200 — 7 = 1193, the mil in the firſt 20 degrees of latitude on the ſpheroid.

Exam. II. *What is the difference of latitude between the parallels of 6 and 40° of latitude on the ſpheroid?*

The complement of 60° is 30°, which doubled is 60°; and twice 40° is 80

Now 60 of courſe and 11 of diſt. gives 9,5, which increaſed by $\frac{1}{5}$ of 0, the exceſs of the next greater, gives 9,7, or 10 m. for the correction to 60

And 80° of courſe with 11,2 of diſt., gives 11 miles of corr. to 40°.

Then 60° × 60 = 3600; and 3600 — 10 = 3590 miles for the di ſtance of the parallel of 60° of latitude from the equator.

Alſo 40° × 60 = 2400; and 2400 — 11 = 2389 miles for the diſtanc of the parallel of 40° of latitude from the equator.

The

Then 3590 — 2389 = 1201 miles for the diff. lat. ſought, which is a mile more than would be on the ſphere.

The equation producing this latter correction was communicated both by Mr. Simpſon, and Mr. Clairaut, when in London this laſt winter.

In order to compare the difference between the reſults from the ſphere and the ſpheroid, the following example is here annexed.

EXAM. *Required the courſe and diſtance from the Lizard to the Iſland of Barbadoes?*

	Longit.	Lat.		Cor.	Com. m p.	Cor.	Cor. m. p.
Lizrd	5° 14′ W	49° 57′ N.	= 2997 m.	11	3469,8	23,0	3446,8
Barbados	59 50 W.	13 00 N.	= 780 m.	5	786,8	6,7	780,1
D. lon.	54 36	d.lat. 36 57	= 2986 m.		2683,0		2666,7
	60	60	775		Mer. d. lat.		Cor. m. d. l.
	3276 m.	1217 m.	1211 m.				

The latitudes are corrected by art. 826, and the meridional parts by art. 825. And 2997 — 11 = 2986. Alſo 780 — 5 = 775.

To find the Courſe

		In the ſphere.				In the ſpheroid.	
A mer. diff. lat.	=	2683	6,57138	Or	=	2667	6,57398
T diff. long.	=	3276	3,51534		=	3276	3,51534
S Radius	=	Rad	10,00000		=	Rad	10,00000
T tangent Courſe	=	50° 41′	10,08672		=	50° 51′	10,08932

To find the Diſtance.

A coſ. Courſe	=	50° 41′	0,19818	Or	=	50° 51′	0,19973
T diff. lat.	=	2217	3,34577		=	2211	3,34459
S Radius	=	Rad	10,00000		=	Rad	10,00000
T Diſtance	=	3499	3,54395		=	3502	3,54432

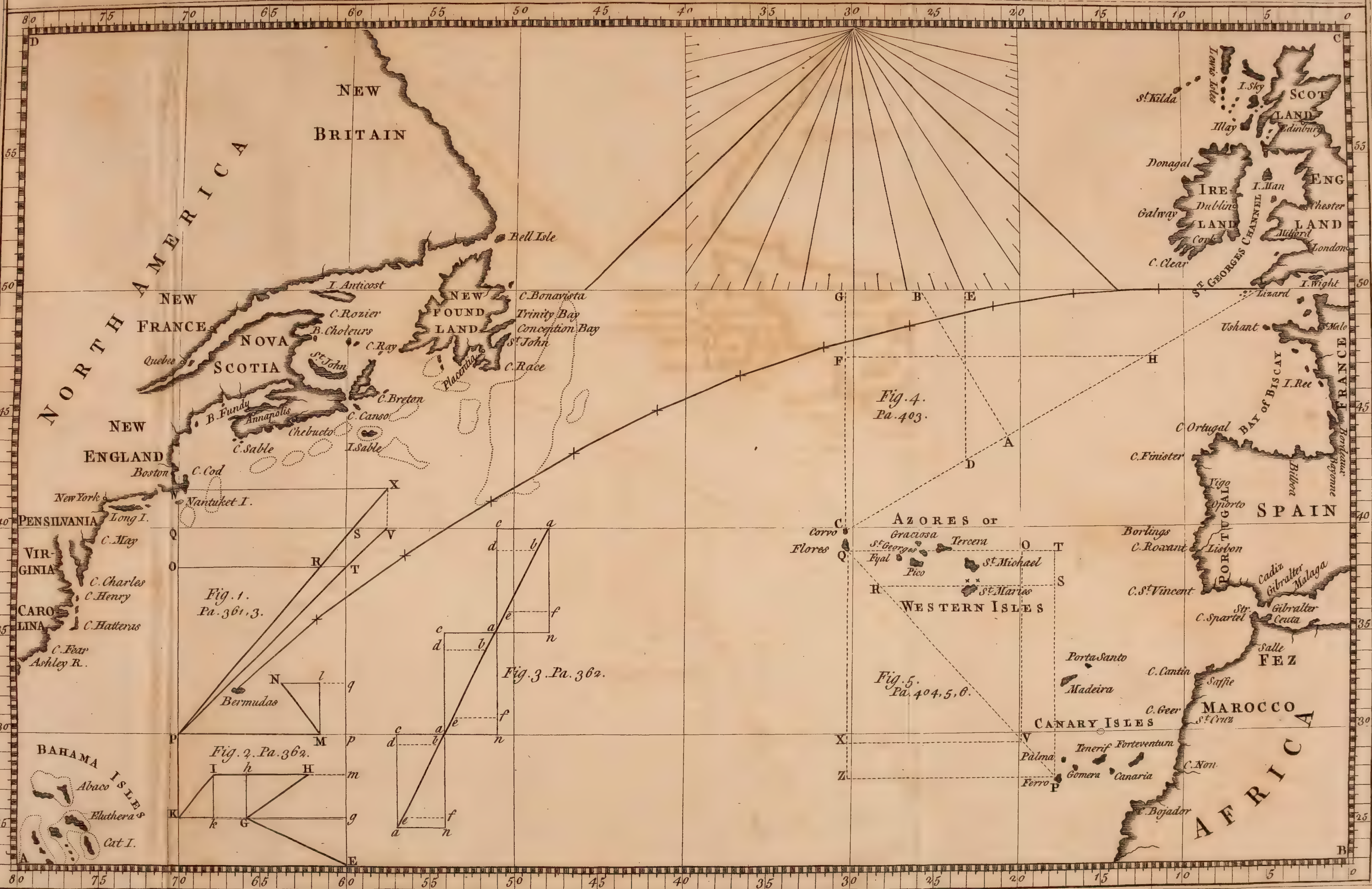
Whence it appears, that the difference between the ſpheric and ſpheroidal operations amounts to 10 minutes in the courſe, and to 3 miles in the diſtance.

The foregoing corrections were made by uſing Sir Iſaac Newton's numbers for the two diameters of the ſpheroid; and altho' ſome authors (on the ſuppoſition that the difference between the equatorial and polar diameters was greater than aſſigned by the illuſtrious Newton) have given much greater corrections, founded on the menſurations in *France* and *Lapland*; yet as thoſe menſurations, at the time the chief of thoſe authors wrote, had not been compared with the menſurations made in *Peru*, therefore the diameters they had choſen were defective of the truth, and conſequently their corrections leſs accurate than could be wiſhed: For the more this intricate problem concerning the figure of the earth has been conſidered, the more inclined are the mathematicians to uſe the diameters aſſigned by Newton.

827. A

A MERCATOR CHART OF THE WESTERN OCEAN.

Pl. VII.



T. Jefferys sculp.

GLOBULAR SAILING. Pl. VIII.

Fig. 1.

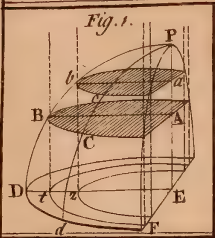


Fig. 2.

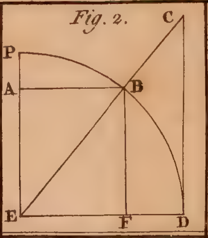


Fig. 3.

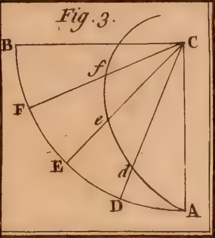


Fig. 4.

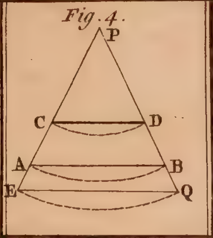


Fig. 5.

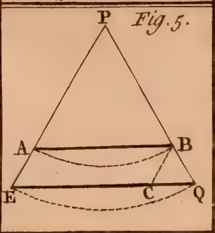


Fig. 6.

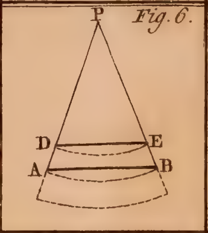


Fig. 7.

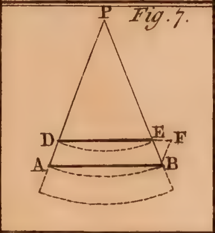


Fig. 8.

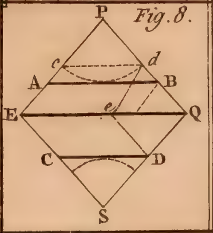


Fig. 9.

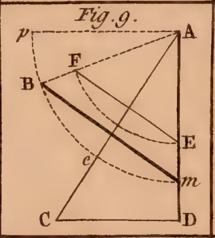


Fig. 10.

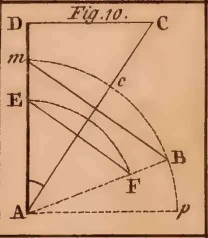


Fig. 11.

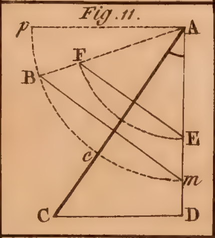


Fig. 12.

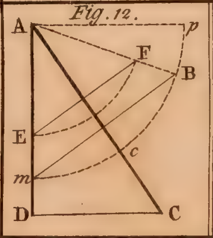


Fig. 13.

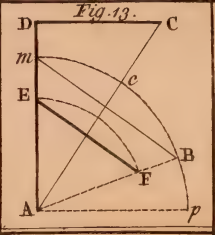


Fig. 14.

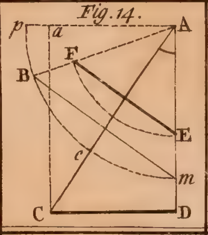


Fig. 15.

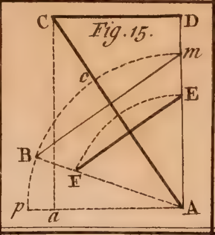


Fig. 16.

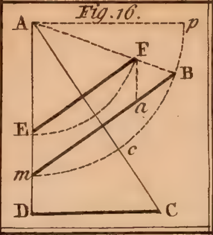


Fig. 17.

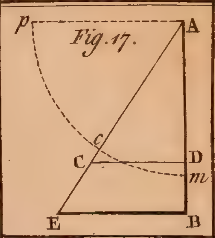


Fig. 18.

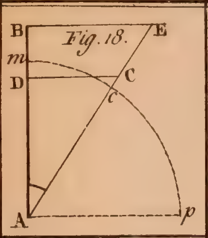


Fig. 19.

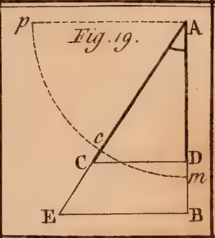


Fig. 20.

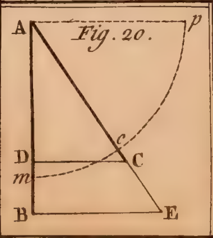


Fig. 21.

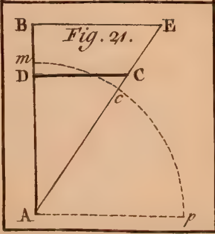


Fig. 22.

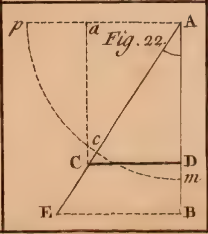


Fig. 23.

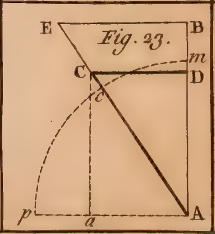


Fig. 24.

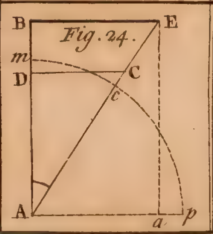


Fig. 25.

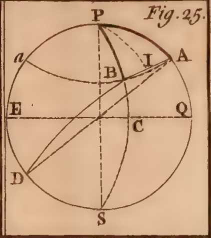


Fig. 26.

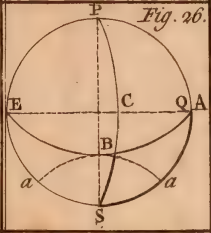


Fig. 27.

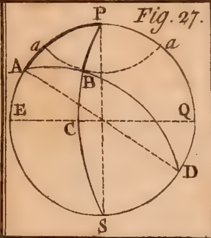


Fig. 28.

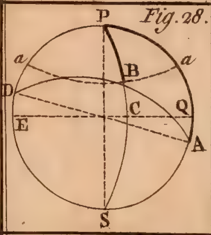


Fig. 29.

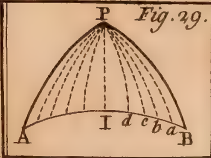


Fig. 30.

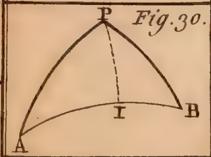
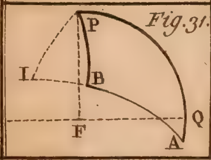


Fig. 31.



J. Jeffrys sculp.

Page 422

827. A TABLE

OF

MERIDIONAL PARTS

To every DEGREE and MINUTE

OF THE

QUADRANT.

Calculated on the ſuppoſition of the ſpheric figure of the EARTH.

Where D. l. ſtands for deg. of lat. and M. P. for meridional parts. ek the degrees of latitude at the top or bottom, and the minutes in e right or left hand columns, and the correſponding meridional parts ill ſtand right againſt the minutes, and in the column ſigned with the gree propoſed.

D. l.	0	1	2	3	4	5	6	7	8	9
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.
0	0,0	60,0	120,0	180,1	240,2	300,4	360,7	421,1	481,6	542,2
1	1,0	61,0	121,0	181,1	241,2	301,4	361,7	422,1	482,6	543,3
2	2,0	62,0	122,0	182,1	242,2	302,4	362,7	423,1	483,6	544,3
3	3,0	63,0	123,0	183,1	243,2	303,4	363,7	424,1	484,6	545,3
4	4,0	64,0	124,0	184,1	244,2	304,4	364,7	425,1	485,6	546,3
5	5,0	65,0	125,0	185,1	245,2	305,4	365,7	426,1	486,6	547,3
6	6,0	66,0	126,0	186,1	246,2	306,4	366,7	427,1	487,6	548,3
7	7,0	67,0	127,0	187,1	247,2	307,4	367,7	428,1	488,6	549,3
8	8,0	68,0	128,0	188,1	248,2	308,4	368,7	429,1	489,6	550,3
9	9,0	69,0	129,0	189,1	249,2	309,4	369,7	430,1	490,7	551,4
10	10,0	70,0	130,0	190,1	250,2	310,4	370,7	431,1	491,7	552,4
11	11,0	71,0	131,0	191,1	251,2	311,4	371,7	432,1	492,7	553,4
12	12,0	72,0	132,0	192,1	252,2	312,4	372,7	433,1	493,7	554,4
13	13,0	73,0	133,0	193,1	253,2	313,4	373,7	434,2	494,7	555,4
14	14,0	74,0	134,0	194,1	254,2	314,4	374,7	435,2	495,7	556,4
15	15,0	75,0	135,0	195,1	255,2	315,4	375,7	436,2	496,7	557,4
16	16,0	76,0	136,0	196,1	256,2	316,4	376,8	437,2	497,7	558,4
17	17,0	77,0	137,0	197,1	257,2	317,5	377,8	438,2	498,7	559,4
18	18,0	78,0	138,0	198,1	258,2	318,5	378,8	439,2	499,8	560,5
19	19,0	79,0	139,0	199,1	259,2	319,5	379,8	440,2	500,8	561,5
20	20,0	80,0	140,0	200,1	260,2	320,5	380,8	441,2	501,8	562,5
21	21,0	81,0	141,0	201,1	261,3	321,5	381,8	442,2	502,8	563,5
22	22,0	82,0	142,0	202,1	262,3	322,5	382,8	443,2	503,8	564,5
23	23,0	83,0	143,0	203,1	263,3	323,5	383,8	444,2	504,8	565,5
24	24,0	84,0	144,0	204,1	264,3	324,5	384,8	445,2	505,8	566,6
25	25,0	85,0	145,0	205,1	265,3	325,5	385,8	446,3	506,8	567,6
26	26,0	86,0	146,0	206,1	266,3	326,5	386,8	447,3	507,8	568,6
27	27,0	87,0	147,0	207,1	267,3	327,5	387,8	448,3	508,9	569,6
28	28,0	88,0	148,0	208,1	268,3	328,5	388,8	449,3	509,9	570,6
29	29,0	89,0	149,0	209,1	269,3	329,5	389,8	450,3	510,9	571,6
30	30,0	90,0	150,0	210,1	270,3	330,5	390,8	451,3	511,9	572,6
31	31,0	91,0	151,0	211,1	271,3	331,5	391,9	452,3	512,9	573,7
32	32,0	92,0	152,0	212,1	272,3	332,5	392,9	453,3	513,9	574,7
33	33,0	93,0	153,1	213,1	273,3	333,5	393,9	454,3	514,9	575,7
34	34,0	94,0	154,1	214,1	274,3	334,5	394,9	455,3	515,9	576,7
35	35,0	95,0	155,1	215,1	275,3	335,5	395,9	456,3	516,9	577,7
36	36,0	96,0	156,1	216,1	276,3	336,5	396,9	457,3	518,0	578,7
37	37,0	97,0	157,1	217,1	277,3	337,5	397,9	458,4	519,0	579,7
38	38,0	98,0	158,1	218,1	278,3	338,6	398,9	459,4	520,0	580,8
39	39,0	99,0	159,1	219,1	279,3	339,6	399,9	460,4	521,0	581,8
40	40,0	100,0	160,1	220,2	280,3	340,6	400,9	461,4	522,0	582,8
41	41,0	101,0	161,1	221,2	281,3	341,6	401,9	462,4	523,0	583,8
42	42,0	102,0	162,1	222,2	282,3	342,6	402,9	463,4	524,0	584,8
43	43,0	103,0	163,1	223,2	283,3	343,6	403,9	464,4	525,0	585,8
44	44,0	104,0	164,1	224,2	284,3	344,6	404,9	465,4	526,0	586,8
45	45,0	105,0	165,1	225,2	285,3	345,6	405,9	466,4	527,1	587,9
46	46,0	106,0	166,1	226,2	286,3	346,6	407,0	467,4	528,1	588,9
47	47,0	107,0	167,1	227,2	287,3	347,6	408,0	468,4	529,1	589,9
48	48,0	108,0	168,1	228,2	288,3	348,6	409,0	469,5	530,1	590,9
49	49,0	109,0	169,1	229,2	289,3	349,6	410,0	470,5	531,1	591,9
50	50,0	110,0	170,1	230,2	290,3	350,6	411,0	471,5	532,1	592,9
51	51,0	111,0	171,1	231,2	291,3	351,6	412,0	472,5	533,1	593,9
52	52,0	112,0	172,1	232,2	292,4	352,6	413,0	473,5	534,1	595,0
53	53,0	113,0	173,1	233,2	293,4	353,6	414,0	474,5	535,1	596,0
54	54,0	114,0	174,1	234,2	294,4	354,6	415,0	475,5	536,2	597,0
55	55,0	115,0	175,1	235,2	295,4	355,6	416,0	476,5	537,2	598,0
56	56,0	116,0	176,1	236,2	296,4	356,6	417,0	477,5	538,2	599,9
57	57,0	117,0	177,1	237,2	297,4	357,6	418,0	478,5	539,2	60[illegible],0
58	58,0	118,0	178,1	238,2	298,4	358,6	419,0	479,5	540,2	601,0
59	59,0	119,0	179,1	239,2	299,4	359,6	420,0	480,5	541,2	602,1
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.
D. l.	0	1	2	3	4	5	6	7	8	9

D. l.	10	11	12	13	14	15	16	17	18	19	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	603,1	664,1	725,3	786,8	848,5	910,5	972,8	1035,3	1098,2	1161,5	0
1	604,1	665,1	726,4	787,9	849,6	911,5	973,8	1036,3	1099,3	1162,5	1
2	605,1	666,1	727,4	788,9	850,6	912,6	974,8	1037,4	1100,3	1163,6	2
3	606,1	667,1	728,4	789,9	851,6	913,6	975,9	1038,4	1101,4	1164,7	3
4	607,1	668,1	729,4	790,9	852,7	914,6	976,9	1039,5	1102,4	1165,7	4
5	608,2	669,2	730,5	792,0	853,7	915,7	978,0	1040,5	1103,5	1166,8	5
6	609,2	670,2	731,5	793,0	854,7	916,7	979,0	1041,6	1104,5	1167,8	6
7	610,2	671,2	732,5	794,0	855,8	917,7	980,0	1042,6	1105,6	1168,9	7
8	611,2	672,2	733,5	795,0	856,8	918,8	981,1	1043,7	1106,6	1170,0	8
9	612,2	673,2	734,6	796,1	857,8	919,8	982,1	1044,7	1107,7	1171,0	9
10	613,2	674,3	735,6	797,1	858,9	920,8	983,2	1045,8	1108,7	1172,1	10
11	614,2	675,3	736,6	798,1	859,9	921,9	984,2	1046,8	1109,8	1173,1	11
12	615,3	676,3	737,6	799,1	861,0	922,9	985,2	1047,9	1110,8	1174,2	12
13	616,3	677,3	738,7	800,2	862,0	923,9	986,3	1048,9	1111,9	1175,2	13
14	617,3	678,3	739,7	801,2	863,0	925,0	987,3	1049,9	1112,9	1176,3	14
15	618,3	679,4	740,7	802,2	864,1	926,0	988,4	1051,0	1114,0	1177,4	15
16	619,3	680,4	741,7	803,2	865,1	927,0	989,4	1052,0	1115,0	1178,4	16
17	620,3	681,4	742,8	804,3	866,1	928,1	990,4	1053,1	1116,1	1179,5	17
18	621,3	682,4	743,8	805,3	867,2	929,1	991,5	1054,1	1117,1	1180,5	18
19	622,4	683,4	744,8	806,3	868,2	930,1	992,5	1055,2	1118,2	1181,6	19
20	623,4	684,5	745,8	807,3	869,2	931,2	993,6	1056,2	1119,2	1182,7	20
21	624,4	685,5	746,9	808,4	870,3	932,2	994,6	1057,3	1120,3	1183,7	21
22	625,4	686,5	747,9	809,4	871,3	933,2	995,6	1058,3	1121,3	1184,8	22
23	626,4	687,5	748,9	810,4	872,3	934,3	996,7	1059,4	1122,4	1185,8	23
24	627,4	688,5	749,9	811,4	873,4	935,3	997,7	1060,4	1123,4	1186,9	24
25	628,5	689,6	751,0	812,5	874,4	936,3	998,8	1061,4	1124,5	1188,0	25
26	629,5	690,6	752,0	813,5	875,4	937,4	999,8	1062,5	1125,5	1189,0	26
27	630,5	691,6	753,0	814,5	876,5	938,4	1000,8	1063,5	1126,6	1190,1	27
28	631,5	692,6	754,0	815,5	877,5	939,4	1001,9	1064,6	1127,6	1191,1	28
29	632,5	693,6	755,1	816,6	878,5	940,5	1002,9	1065,6	1128,7	1192,2	29
30	633,5	694,7	756,1	817,6	879,6	941,5	1004,0	1066,7	1129,7	1193,2	30
31	634,6	695,7	757,1	818,6	880,6	942,5	1005,0	1067,7	1130,8	1194,3	31
32	635,6	696,7	758,1	819,6	881,6	943,6	1006,1	1068,8	1131,8	1195,4	32
33	636,6	697,7	759,2	820,7	882,7	944,6	1007,1	1069,8	1132,9	1196,4	33
34	637,6	698,7	760,2	821,7	883,7	945,6	1008,1	1070,9	1134,0	1197,5	34
35	638,6	699,8	761,2	822,7	884,7	946,7	1009,2	1072,0	1135,1	1198,5	35
36	639,6	700,8	762,2	823,7	885,8	947,7	1010,2	1073,0	1136,1	1199,6	36
37	640,7	701,8	763,3	824,8	886,8	948,7	1011,3	1074,1	1137,2	1200,7	37
38	641,7	702,8	764,3	825,8	887,8	949,8	1012,3	1075,1	1138,2	1201,7	38
39	642,7	703,8	765,3	826,8	888,9	950,8	1013,4	1076,2	1139,3	1202,8	39
40	643,7	704,9	766,3	827,9	889,9	951,9	1014,4	1077,2	1140,3	1203,9	40
41	644,7	705,9	767,4	828,9	890,9	952,9	1015,4	1078,3	1141,4	1204,9	41
42	645,7	706,9	768,4	829,9	892,0	953,9	1016,5	1079,3	1142,4	1206,0	42
43	646,8	707,9	769,4	831,0	893,0	955,0	1017,5	1080,4	1143,5	1207,1	43
44	647,8	708,9	770,4	832,0	894,0	956,0	1018,6	1081,4	1144,6	1208,1	44
45	648,8	710,0	771,5	833,0	895,1	957,1	1019,6	1082,5	1145,6	1209,2	45
46	649,8	711,0	772,5	834,1	896,1	958,1	1020,6	1083,5	1146,7	1210,2	46
47	650,8	712,0	773,5	835,1	897,1	959,2	1021,7	1084,6	1147,7	1211,3	47
48	651,8	713,0	774,5	836,1	898,2	960,2	1022,7	1085,6	1148,8	1212,4	48
49	652,9	714,1	775,6	837,2	899,2	961,3	1023,8	1086,7	1149,8	1213,4	49
50	653,9	715,1	776,6	838,2	900,2	962,3	1024,8	1087,7	1150,9	1214,5	50
51	654,9	716,1	777,6	839,2	901,2	963,4	1025,9	1088,8	1152,0	1215,5	51
52	655,9	717,1	778,6	840,3	902,3	964,4	1026,9	1089,8	1153,0	1216,6	52
53	656,9	718,2	779,7	841,3	903,3	965,5	1028,0	1090,9	1154,1	1217,7	53
54	657,9	719,2	780,7	842,3	904,3	966,5	1029,0	1091,9	1155,1	1218,7	54
55	659,0	720,2	781,7	843,4	905,4	967,6	1030,1	1093,0	1156,2	1219,8	55
56	660,0	721,2	782,7	844,4	906,4	968,6	1031,1	1094,0	1157,2	1220,9	56
57	661,0	722,3	783,8	845,4	907,4	969,6	1032,2	1095,1	1158,3	1221,9	57
58	662,0	723,3	784,8	846,5	908,4	970,7	1033,2	1096,1	1159,4	1223,0	58
59	663,0	724,3	785,8	847,5	909,5	971,7	1034,3	1097,2	1160,4	1224,1	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	10	11	12	13	14	15	16	17	18	19	D. l.

D. l.	20	21	22	23	24	25	26	27	28	29	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	1225,1	1289,2	1353,7	1418,7	1484,1	1550,0	1616,5	1683,6	1751,2	1819,5	0
1	1226,2	1290,2	1354,8	1419,7	1485,2	1551,1	1617,6	1684,7	1752,3	1820,6	1
2	1227,3	1291,3	1355,8	1420,8	1486,3	1552,2	1618,7	1685,8	1753,4	1821,7	2
3	1228,3	1292,4	1356,9	1421,9	1487,3	1553,3	1619,8	1686,9	1754,6	1822,9	3
4	1229,4	1293,5	1358,0	1423,0	1488,4	1554,4	1620,9	1688,0	1755,7	1824,0	4
5	1230,4	1294,5	1359,0	1424,1	1489,5	1555,5	1622,0	1689,1	1756,8	1825,2	5
6	1231,5	1295,6	1360,1	1425,1	1490,6	1556,6	1623,2	1690,3	1758,0	1826,3	6
7	1232,6	1296,7	1361,2	1426,2	1491,7	1557,7	1624,3	1691,4	1759,1	1827,5	7
8	1233,6	1297,8	1362,3	1427,3	1492,8	1558,8	1625,4	1692,5	1760,2	1828,6	8
9	1234,7	1298,8	1363,3	1428,4	1493,9	1559,9	1626,5	1693,6	1761,4	1829,7	9
10	1235,8	1299,9	1364,4	1429,5	1495,0	1561,0	1627,6	1694,8	1762,5	1830,9	10
11	1236,8	1301,0	1365,5	1430,6	1496,1	1562,1	1628,7	1695,9	1763,6	1832,0	11
12	1237,9	1302,0	1366,6	1431,7	1497,2	1563,2	1629,8	1697,0	1764,8	1833,2	12
13	1239,0	1303,1	1367,6	1432,8	1498,3	1564,3	1631,0	1698,1	1765,9	1834,3	13
14	1240,0	1304,2	1368,7	1433,9	1499,4	1565,4	1632,1	1699,3	1767,0	1835,5	14
15	1241,1	1305,3	1369,8	1434,9	1500,5	1566,5	1633,2	1700,4	768,2	1836,6	15
16	1242,2	1306,3	1370,9	1436,0	1501,6	1567,6	1634,3	1701,5	1769,3	1837,8	16
17	1243,2	1307,4	1372,0	1437,1	1502,7	1568,7	1635,4	1702,6	1770,5	1838,9	17
18	1244,3	1308,5	1373,1	1438,2	1503,8	1569,8	1636,5	1703,8	1771,6	1840,1	18
19	1245,4	1309,6	1374,2	1439,3	1504,9	1571,0	1637,7	1704,9	1772,7	1841,2	19
20	1246,4	1310,6	1375,3	1440,4	1506,0	1572,1	1638,8	1706,0	1773,9	1842,4	20
21	1247,5	1311,7	1376,4	1441,5	1507,1	1573,2	1639,9	1707,1	1775,0	1843,5	21
22	1248,6	1312,8	1377,4	1442,6	1508,2	1574,3	1641,0	1708,3	1776,1	1844,6	22
23	1249,6	1313,8	1378,5	1443,7	1509,3	1575,4	1642,1	1709,4	1777,2	1845,8	23
24	1250,7	1314,9	1379,6	1444,7	1510,4	1576,5	1643,2	1710,5	1778,4	1846,9	24
25	1251,8	1316,0	1380,7	1445,8	1511,5	1577,6	1644,3	1711,6	1779,5	1848,1	25
26	1252,8	1317,1	1381,8	1446,9	1512,6	1578,7	1645,5	1712,8	1780,6	1849,2	26
27	1253,9	1318,1	1382,8	1448,0	1513,7	1579,8	1646,6	1713,9	1781,8	1850,4	27
28	1255,0	1319,2	1383,9	1449,1	1514,8	1580,9	1647,7	1715,0	1783,0	1851,5	28
29	1256,0	1320,3	1385,0	1450,2	1515,9	1582,0	1648,8	1716,1	1784,1	1852,7	29
30	1257,1	1321,4	1386,1	1451,3	1517,0	1583,2	1649,9	1717,3	1785,2	1853,8	30
31	1258,2	1322,4	1387,2	1452,4	1518,1	1584,3	1651,0	1718,4	1786,4	1855,0	31
32	1259,2	1323,5	1388,3	1453,5	1519,2	1585,4	1652,2	1719,5	1787,5	1856,1	32
33	1260,3	1324,6	1389,4	1454,6	1520,3	1586,5	1653,3	1720,7	1788,6	1857,2	33
34	1261,4	1325,7	1390,4	1455,7	1521,4	1587,6	1654,4	1721,8	1789,8	1858,4	34
35	1262,4	1326,7	1391,5	1456,8	1522,5	1588,7	1655,5	1722,9	1790,9	1859,6	35
36	1263,5	1327,8	1392,6	1457,9	1523,6	1589,8	1656,6	1724,0	1792,1	1860,7	36
37	1264,6	1328,9	1393,7	1458,9	1524,7	159 ,9	1657,8	1725,2	1793,2	1861,9	37
38	1265,6	1330,0	1394,8	1460,0	1525,8	1592,0	1658,9	1726,3	1794,3	1863,0	38
39	1266,7	1331,1	1395,8	1461,1	1526,9	1593,2	1660,0	1727,4	1795,5	2864,2	39
40	1267,8	1332,1	1396,0	1462,2	1528,0	1594,3	1661,1	1728,6	1796,6	1865,3	40
41	1268,8	1333,2	1398,0	1463,3	1529,1	1595,4	1662,2	1729,7	1797,8	1866,5	41
42	1269,9	1334,2	1399,1	1464,4	1530,2	1596,5	1663,4	1730,8	1798,9	1867,6	42
43	1271,0	1335,3	1400,2	1465,5	1531,3	1597,6	1664,5	1731,9	1800,0	1868,8	43
44	1272,1	1336,4	1401,3	1466,6	1532,4	1598,7	1665,6	1733,1	1801,2	1869,9	44
45	1273,1	1337,5	1402 4	1467,7	1533,5	1599,8	1666,7	1734,2	1802,3	1871,1	45
46	1274,2	1338,6	1403,4	1468,8	1534,6	1600,9	1667,8	1735,3	1803,5	1872,2	46
47	1275,3	1339,7	1404,5	1469,8	1535,7	1602,0	1669,0	1736,5	1804,6	1873,4	47
48	1276,3	1340,7	1405,6	1470,9	1536,8	1603,1	1670,1	1737,6	1805,7	1874,5	48
49	1277,4	1341,8	1406,7	1472,0	1537,9	1604,3	1671,2	1738,7	1806,9	1875,7	49
50	1278,5	1342,9	1407,8	1473,1	1539.0	1605,4	1672,3	1739,9	1808,0	1876,8	50
51	1279,5	1344,0	1408,8	1474,2	1540,1	1606,5	1673,4	1741,0	1809,2	1878,0	51
52	1280,6	1345,0	1409,9	1475,3	1541,2	1607,6	1674,6	1742,1	1810,3	1879,2	52
53	1281,7	1346,1	411,0	1476,4	1542,3	1608,7	1675,7	1743,2	1811,4	1880,3	53
54	1282,7	1347,2	1412,1	1477,5	1543,4	1609,8	1676,9	1744,4	1812,6	1881,5	54
55	1283,8	1348,3	1413,2	1478,6	1544,5	1610,9	1678,0	1745,5	1813,7	1882,6	55
56	1284,9	1349,4	1414,3	1479,7	1545,6	1612,0	1679,1	1746,6	1814,9	1883,8	56
57	1286,0	1350,4	1415,4	1480,8	1546,7	1613,1	1680,2	1747,8	1816,0	1884,9	57
58	1287,0	1351,5	1416,5	1481,9	1547,8	1614,2	1681,3	1748,9	1817,2	1886,1	58
59	1288,1	1352,6	1417,6	1483 0	1548,9	1615,4	1682,4	1750,0	1818,3	1887,2	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	20	21	22	23	24	25	26	27	28	29	D. l.

D. l.	30	31	32	33	34	35	36	37	38	39	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	1888,4	1958,0	2028,4	2099,6	2171,5	2244,3	2318,0	2392,7	2468,3	2545,0	0
1	1889,5	1959,2	2029,6	2100,7	2172,7	2245,5	2319,3	2393,9	2469,6	2546,2	1
2	1890,7	1960,4	2030,7	2101,9	2173,9	2246,8	2320,5	2395,2	2470,8	2547,5	2
3	1891,9	1961,	2031,9	2103,1	2175,1	2248,0	2321,7	2396,4	2472,1	2548,8	3
4	1893,0	1962,7	2033,1	2104,3	2176,3	2249,2	2323,0	2397,7	2473,4	2550,1	4
5	1894,1	1963,9	2034,3	2105,5	2177,5	2250,4	2324,2	2398,9	2474,6	2551,4	5
6	1895,3	1965,0	2035,5	2106,7	2178,7	2251,6	2325,4	2400,2	2475,9	2552,7	6
7	1896,5	1966,2	2036,7	2107,9	2180,0	2252,9	2326,7	2401,4	2477,1	2554,0	7
8	1897,6	1967,4	2037,8	2109,1	2181,2	2254,1	2327,9	2402,7	2478,5	2555,3	8
9	1898,8	1968,5	2039,0	2110,3	2182,4	2255,3	2329,2	2403,9	2479,7	2556,6	9
10	1899,9	1969,7	2040,	2111,5	2183,6	2256,5	2330,4	2405.2	2481,0	2557,8	10
11	1901,1	1970,9	2041,4	2112,7	2184,8	2257,8	2331,6	2406,4	2482,3	2559,1	11
12	1902,3	1972,0	2042,6	2113,9	2186,0	2259,0	2332,9	2407,7	2483,5	2560,4	12
13	1903,4	1973,2	2043,8	2115,1	2187,2	2260,2	2334,1	2409,0	2484,8	2561,7	13
14	1904,6	1974,4	2044,9	2116,3	2188,4	2261,4	2335,3	2410,2	2486,1	2563,0	14
15	1905,7	1975,6	2046,1	2117,5	2189,6	2262,7	2336,6	2411,5	2487,4	2564,3	15
16	1906,9	1976,8	2047,3	2118,7	2190,8	2263,9	2337,8	2412,7	2488,6	2565,6	16
17	1908,1	1977,9	2048,5	2119,8	2192,0	2265,1	2339,0	2414,0	2489,9	2566,9	17
18	1909,2	1979,1	2049,7	2121,0	2193,3	2266,3	2340,3	2415,2	2491,2	2568,2	18
19	1910,4	1980,3	2050,8	2122,2	2194,5	2267,6	2341,5	2416,5	2492,5	2569,5	19
20	1911,5	1981,4	2052,0	2123,4	2195,7	2268,8	2342,8	2417,8	2493,7	2570,7	20
21	1912,7	1982,6	2053,2	2124,6	2196,9	2270,0	2344,0	2419,0	2495,0	2572,0	21
22	1913,8	983,7	2054,4	2125,8	2198,1	2271,2	2345,3	2420,3	2496,3	2573,3	22
23	1915,0	1984,9	2055,6	2127,	2199,3	2272,5	2346,5	2421,5	2497,6	2574,6	23
24	1916,2	1986,1	2056,8	2128,2	2200,5	2273,7	2347,8	2422,8	2498,8	2575,9	24
25	1917,3	1987,3	2058,0	2129,4	2201,7	2274,9	2349,0	2424,0	2500,1	2577,2	25
26	1918,5	1988,4	2059,1	2130,6	2203,0	2276,1	2350,2	2425,3	2501,4	2578,5	26
27	1919,6	1989,6	206 ,3	2131,8	2204,2	2277,4	2351,5	2426,5	2502,7	2579,8	27
28	1920,8	1990,8	2061,5	2133,0	2205,4	2278,6	2352,7	2427,8	2503,9	2581,1	28
29	1921,9	1992,0	2062,7	2134,2	2206,6	2279,8	2354,0	2429,1	2505,2	2582,4	29
30	1923,1	993,1	2063,9	2135,4	2207,8	2281,0	2355,2	2430.3	2506,5	2583,7	30
31	1924,3	1994,3	206 ,	2136,6	2209,0	2282,3	2356,5	2431,6	2507,8	2585,0	31
32	1925,4	1995,	2066,2	2137,8	2210,2	2283,5	2357,7	2432,9	2509,0	2586,3	32
33	1926,6	1996,6	2067,4	2139,0	2211,4	2284,7	2358,9	2434.1	2510,3	2587,6	33
34	1927,8	1997,8	2068,6	2140,2	2212,7	2286,0	2360,2	2435,4	2511,6	2588,9	34
35	1928,9	1999,0	2069,8	2141,4	2213,9	2287,2	2361,4	2436,7	2512,9	2590,2	35
36	1930,1	2000,2	2071,	2142,6	2215,1	2288,4	2362,7	2437,9	2514,2	2591,5	36
37	1931,3	2001,3	2072,2	2143,8	2216,3	2289,7	2363,9	2439,2	2515,4	2592,8	37
38	1932,4	2002,5	2073,4	2145,0	2217,5	2290,9	2365,2	2440,4	2516,7	2594,1	38
39	1933,6	2003,7	2074,6	2146,2	2218,7	2292,1	2366,4	2441,7	2518,0	2595,4	39
40	1934,7	2004,9	2075,7	2147,4	2219,9	2293,3	2367,7	2443,0	2519,3	2596,7	40
41	1935,9	2006,0	2076,9	2148,6	2221,2	2294,6	2368,9	2444,2	2520,6	2598,0	41
42	1937,1	2007,2	2078,1	2149,8	2222,4	2295,8	2370,2	2445,5	2521,8	2599,3	42
43	1938,2	2008,4	2079,3	2151,0	2223,6	2297,0	2371,4	2446,8	2523,1	2600,6	43
44	1939,4	2009,6	2080,5	2152,2	2224,8	2298,3	2372,7	2448,0	2524,4	2601,9	44
45	1940,5	2010,7	2081,7	2153,4	2226,0	2299,5	2373,9	2449,3	2525,7	2603,2	45
46	1941,7	2011,9	2082,9	2154,6	2227,2	2300,7	2375,2	2450,6	2527,0	2604,5	46
47	1942,9	2013,1	2084,1	2155,8	2228,5	2302,0	2376,4	2451,8	2528,3	2605,8	47
48	1944,0	2014,3	2085,3	2157,0	2229,7	2303,2	2377,7	2453,1	2529,6	2607,1	48
49	1945,2	2015,4	2086,5	2158,2	2230,9	2304,4	2378,9	2454,3	2530,8	2608,4	49
50	1946,4	2016,6	2087,7	2159,4	2232,1	2305,7	2380,1	2455,6	2532,1	2609,7	50
51	1947,5	2017,8	2088,9	2160,7	2233,3	2306,9	2381,4	2456,9	2533,4	2611,0	51
52	1948,7	2019,0	2090,1	2161,9	2234,6	2308,1	2382,6	2458,1	2534,7	2612,3	52
53	1949,9	2020,2	2091,3	2163,1	2235,8	2309,4	2383,9	2459,4	2536,0	2613,6	53
54	1951,0	2021,3	2092,5	2164,3	2237,0	2310,6	2385,1	2460,7	2537,2	2614,9	54
55	1952,2	2022,5	2093,7	2165,5	2238,2	2311,8	2386,4	2461,9	2538,5	2616,2	55
56	1953,4	2023,7	2094,9	2166,7	2239,4	2313,1	2387,6	2463,2	2539,8	2617,5	56
57	1954,5	2024,9	2096,1	2167,9	2240,7	2314,3	2388,9	2464,5	2541,1	2618,8	57
58	1955,7	2026,0	2097,3	2169,1	2241,9	2315,5	2390,2	2465,8	2542,4	2620,1	58
59	1956,9	2027,2	2098,5	2170,3	2243,1	2316,7	2391,4	2467,0	2543,7	2621,4	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	30	31	32	33	34	35	36	37	38	39	D. l.

D. l.	20	21	22	23	24	25	26	27	28	29	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	1225,1	1289,2	1353,7	1418,7	1484,1	1550,0	1616,5	1683,6	1751,2	1819,5	0
1	1226,2	1290,2	1354,8	1419,7	1485,2	1551,1	1617,6	1684,7	1752,3	1820,6	1
2	1227,3	1291,3	1355,8	1420,8	1486,3	1552,2	1618,7	1685,8	1753,4	1821,7	2
3	1228,3	1292,4	1356,9	1421,9	1487,3	1553,3	1619,8	1686,9	1754,6	1822,9	3
4	1229,4	1293,5	1358,0	1423,0	1488,4	1554,4	1620,9	1688,0	1755,7	1824,0	4
5	1230,4	1294,5	1359,0	1424,1	1489,5	1555,5	1622,0	1689,1	1756,8	1825,2	5
6	1231,5	1295,6	1360,1	1425,1	1490,6	1556,6	1623,2	1690,3	1758,0	1826,3	6
7	1232,6	1296,7	1361,2	1426,2	1491,7	1557,7	1624,3	1691,4	1759,1	1827,5	7
8	1233,6	1297,8	1362,3	1427,3	1492,8	1558,8	1625,4	1692,5	1760,2	1828,6	8
9	1234,7	1298,8	1363,3	1428,4	1493,9	1559,9	1626,5	1693,6	1761,4	1829,7	9
10	1235,8	1299,9	1364,4	1429,5	1495,0	1561,0	1627,6	1694,8	1762,5	1830,9	10
11	1236,8	1301,0	1365,5	1430,6	1496,1	1562,1	1628,7	1695,9	1763,6	1832,0	11
12	1237,9	1302,0	1366,6	1431,7	1497,2	1563,2	1629,8	1697,0	1764,8	1833,2	12
13	1239,0	1303,1	1367,6	1432,8	1498,3	1564,3	1631,0	1698,1	1765,9	1834,3	13
14	1240,0	1304,2	1368,7	1433,9	1499,4	1565,4	1632,1	1699,3	1767,0	1835,5	14
15	1241,1	1305,3	1369,8	1434,9	1500,5	1566,5	1633,2	1700,4	1768,2	1836,6	15
16	1242,2	1306,3	1370,9	1436,0	1501,6	1567,6	1634,3	1701,5	1769,3	1837,8	16
17	1243,2	1307,4	1372,0	1437,1	1502,7	1568,7	1635,4	1702,6	1770,5	1838,9	17
18	1244,3	1308,5	1373,1	1438,2	1503,8	1569,8	1636,5	1703,8	1771,6	1840,1	18
19	1245,4	1309,6	1374,2	1439,3	1504,9	1571,0	1637,7	1704,9	1772,7	1841,2	19
20	1246,4	1310,6	1375,3	1440,4	1506,0	1572,1	1638,8	1706,0	1773,9	1842,4	20
21	1247,5	1311,7	1376,4	1441,5	1507,1	1573,2	1639,9	1707,1	1775,0	1843,5	21
22	1248,6	1312,8	1377,4	1442,6	1508,2	1574,3	1641,0	1708,3	1776,1	1844,6	22
23	1249,6	1313,8	1378,5	1443,7	1509,3	1575,4	1642,1	1709,4	1777,2	1845,8	23
24	1250,7	1314,9	1379,6	1444,7	1510,4	1576,5	1643,2	1710,5	1778,4	1846,9	24
25	1251,8	1316,0	1380,7	1445,8	1511,5	1577,6	1644,3	1711,6	1779,5	1848,1	25
26	1252,8	1317,1	1381,8	1446,9	1512,6	1578,7	1645,5	1712,8	1780,6	1849,2	26
27	1253,9	1318,1	1382,8	1448,0	1513,7	1579,8	1646,6	1713,9	1781,8	1850,4	27
28	1255,0	1319,2	1383,9	1449,1	1514,8	1580,9	1647,7	1715,0	1783,0	1851,5	28
29	1256,0	1320,3	1385,0	1450,2	1515,9	1582,0	1648,8	1716,1	1784,1	1852,7	29
30	1257,1	1321,4	1386,1	1451,3	1517,0	1583,2	1649,9	1717,3	1785,2	1853,8	30
31	1258,2	1322,4	1387,2	1452,4	1518,1	1584,3	1651,0	1718,4	1786,4	1855,0	31
32	1259,2	1323,5	1388,3	1453,5	1519,2	1585,4	1652,2	1719,5	1787,5	1856,1	32
33	1260,3	1324,6	1389,4	1454,6	1520,3	1586,5	1653,3	1720,7	1788,6	1857,2	33
34	1261,4	1325,7	1390,4	1455,7	1521,4	1587,6	1654,4	1721,8	1789,8	1858,4	34
35	1262,4	1326,7	1391,5	1456,8	1522,5	1588,7	1655,5	1722,9	1790,9	1859,6	35
36	1263,5	1327,8	1392,6	1457,9	1523,6	1589,8	1656,6	1724,0	1792,1	1860,7	36
37	1264,6	1328,9	1393,7	1458,9	1524,7	1590,9	1657,8	1725,2	1793,2	1861,9	37
38	1265,6	1330,0	1394,8	1460,0	1525,8	1592,0	1658,9	1726,3	1794,3	1863,0	38
39	1266,7	1331,1	1395,8	1461,1	1526,9	1593,2	1660,0	1727,4	1795,5	1864,2	39
40	1267,8	1332,1	1396,9	1462,2	1528,0	1594,3	1661,1	1728,6	1796,6	1865,3	40
41	1268,8	1333,2	1398,0	1463,3	1529,1	1595,4	1662,2	1729,7	1797,8	1866,5	41
42	1269,9	1334,2	1399,1	1464,4	1530,2	1596,5	1663,4	1730,8	1798,9	1867,6	42
43	1271,0	1335,3	1400,2	1465,5	1531,3	1597,6	1664,5	1731,9	1800,0	1868,8	43
44	1272,1	1336,4	1401,3	1466,6	1532,4	1598,7	1665,6	1733,1	1801,2	1869,9	44
45	1273,1	1337,5	1402,4	1467,7	1533,5	1599,8	1666,7	1734,2	1802,3	1871,1	45
46	1274,2	1338,6	1403,4	1468,8	1534,6	1600,9	1667,8	1735,3	1803,5	1872,2	46
47	1275,3	1339,7	1404,5	1469,8	1535,7	1602,0	1669,0	1736,5	1804,6	1873,4	47
48	1276,3	1340,7	1405,6	1470,9	1536,8	1603,1	1670,1	1737,6	1805,7	1874,5	48
49	1277,4	1341,8	1406,7	1472,0	1537,9	1604,3	1671,2	1738,7	1806,9	1875,7	49
50	1278,5	1342,9	1407,8	1473,1	1539,0	1605,4	1672,3	1739,9	1808,0	1876,8	50
51	1279,5	1344,0	1408,8	1474,2	1540,1	1606,5	1673,4	1741,0	1809,2	1878,0	51
52	1280,6	1345,0	1409,9	1475,3	1541,2	1607,6	1674,6	1742,1	1810,3	1879,2	52
53	1281,7	1346,1	1411,0	1476,4	1542,3	1608,7	1675,7	1743,2	1811,4	1880,3	53
54	1282,7	1347,2	1412,1	1477,5	1543,4	1609,8	1676,9	1744,4	1812,6	1881,5	54
55	1283,8	1348,3	1413,2	1478,6	1544,5	1610,9	1678,0	1745,5	1813,7	1882,6	55
56	1284,9	1349,4	1414,3	1479,7	1545,6	1612,0	1679,1	1746,6	1814,9	1883,8	56
57	1286,0	1350,4	1415,4	1480,8	1546,7	1613,1	1680,2	1747,8	1816,0	1884,9	57
58	1287,0	1351,5	1416,5	1481,9	1547,8	1614,2	1681,3	1748,9	1817,2	1886,1	58
59	1288,1	1352,6	1417,6	1483,0	1548,9	1615,4	1682,4	1750,0	1818,3	1887,2	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	20	21	22	23	24	25	26	27	28	29	D. l.

D. l.	30	31	32	33	34	35	36	37	38	39	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	1888,4	1958,0	2028,4	2099,6	2171,5	2244,3	2318,0	2392,7	2468,3	2545,0	0
1	1889,5	1959,2	2029,6	2100,7	2172,7	2245,5	2319,3	2393,9	2469,6	2546,2	1
2	1890,7	1960,4	2030,7	2101,9	2173,9	2246,8	2320,5	2395,2	2470,8	2547,5	2
3	1891,9	1961,	2031,9	2103,1	2175,1	2248,0	2321,7	2396,4	2472,1	2548,8	3
4	1893,0	1962,7	2033,1	2104,3	2176,3	2249,2	2323,0	2397,7	2473,4	2550,1	4
5	1894,1	1963,9	2034,3	2105,5	2177,5	2250,4	2324,2	2398,9	2474,6	2551,4	5
6	1895,3	1965,0	2035,5	2106,7	2178,7	2251,6	2325,4	2400,2	2475,9	2552,7	6
7	1896,5	1966,2	2036,7	2107,9	2180,0	2252,9	2326,7	2401,4	2477,1	2554,0	7
8	1897,6	1967,4	2037,8	2109,	2181,2	2254,1	2327,9	2402,7	2478,5	2555,3	8
9	1898,8	1968,5	2039,0	2110,3	2182,4	2255,3	2329,2	2403,9	2479,7	2556,6	9
10	1899,9	1969,7	2040,	2111,5	2183,6	2256,5	2330,4	2405,2	2481,0	2557,8	10
11	1901,1	1970,9	2041,4	2112,7	2184,8	2257,8	2331,6	2406,4	2482,3	2559,1	11
12	1902,3	1972,0	2042,6	2113,9	2186,0	2259,0	2332,9	2407,7	2483,5	2560,4	12
13	1903,4	1973,2	2043,8	2115,1	2187,2	2260,2	2334,1	2409,0	2484,8	2561,7	13
14	1904,6	1974,4	2044,9	2116,3	2188,4	2261,4	2335,3	2410,2	2486,1	2563,0	14
15	1905,7	1975,6	2046,1	2117,5	2189,6	2262,7	2336,6	2411,5	2487,4	2564,3	15
16	1906,9	1976,8	2047,3	2118,7	2190,8	2263,9	2337,8	2412,7	2488,6	2565,6	16
17	1908,1	1977,9	2048,5	2119,8	2192,0	2265,1	2339,0	2414,0	2489,9	2566,9	17
18	1909,2	1979,1	2049,7	2121,0	2193,3	2266,3	2340,3	2415,2	2491,2	2568,2	18
19	1910,4	1980,3	2050,8	2122,2	2194,5	2267,6	2341,5	2416,5	2492,5	2569,5	19
20	1911,5	1981,4	2052,0	2123,4	2195,7	2268,8	2342,8	2417,8	2493,7	2570,7	20
21	1912,7	1982,6	2053,2	2124,6	2196,9	2270,0	2344,0	2419,0	2495,0	2572,0	21
22	1913,8	1983,7	2054,4	2125,8	2198,1	2271,2	2345,3	2420,3	2496,3	2573,3	22
23	1915,0	1984,9	2055,6	2127,0	2199,3	2272,5	2346,5	2421,5	2497,6	2574,6	23
24	1916,2	1986,1	2056,8	2128,2	2200,5	2273,7	2347,8	2422,8	2498,8	2575,9	24
25	1917,3	1987,3	2058,0	2129,4	2201,7	2274,9	2349,0	2424,0	2500,1	2577,2	25
26	1918,5	1988,4	2059,1	2130,6	2203,0	2276,1	2350,2	2425,3	2501,4	2578,5	26
27	1919,6	1989,6	2060,3	2131,8	2204,2	2277,4	2351,5	2426,5	2502,7	2579,8	27
28	1920,8	1990,8	2061,5	2133,0	2205,4	2278,6	2352,7	2427,8	2503,9	2581,1	28
29	1921,9	1992,0	2062,7	2134,2	2206,6	2279,8	2354,0	2429,1	2505,2	2582,4	29
30	1923,1	1993,1	2063,9	2135,4	2207,8	2281,0	2355,2	2430,3	2506,5	2583,7	30
31	1924,3	1994,3	206 ,	2136,6	2209,0	2282,3	2356,5	2431,6	2507,8	2585,0	31
32	1925,4	1995,5	2066,2	2137,8	2210,2	2283,5	2357,7	2432,9	2509,0	2586,3	32
33	1926,6	1996,6	2067,4	2139,0	2211,4	2284,7	2358,9	2434,1	2510,3	2587,6	33
34	1927,8	1997,8	2068,6	2140,2	2212,7	2286,0	2360,2	2435,4	2511,6	2588,9	34
35	1928,9	1999,0	2069,8	2141,4	2213,9	2287,2	2361,4	2436,7	2512,9	2590,2	35
36	1930,1	2000,2	2071,	2142,6	2215,1	2288,4	2362,7	2437,9	2514,2	2591,5	36
37	1931,3	2001,3	2072,2	2143,8	2216,3	2289,7	2363,9	2439,2	2515,4	2592,8	37
38	1932,4	2002,5	2073,4	2145,0	2217,5	2290,9	2365,2	2440,4	2516,7	2594,1	38
39	1933,6	2003,7	2074,6	2146,2	2218,7	2292,1	2366,4	2441,7	2518,0	2595,4	39
40	1934,7	2004,9	2075,7	2147,4	2219,9	2293,3	2367,7	2443,0	2519,3	2596,7	40
41	1935,9	2006,0	2076,9	2148,6	2221,2	2294,6	2368,9	2444,2	2520,6	2598,0	41
42	1937,1	2007,2	2078,1	2149,8	2222,4	2295,8	2370,2	2445,5	2521,8	2599,3	42
43	1938,2	2008,4	2079,3	2151,0	2223,6	2297,0	2371,4	2446,8	2523,1	2600,6	43
44	1939,4	2009,6	2080,5	2152,2	2224,8	2298,3	2372,7	2448,0	2524,4	2601,9	44
45	1940,5	2010,7	2081,7	2153,4	2226,0	2299,5	2373,9	2449,3	2525,7	2603,2	45
46	1941,7	2011,9	2082,9	2154,6	2227,2	2300,7	2375,2	2450,6	2527,0	2604,5	46
47	1942,9	2013,1	2084,1	2155,8	2228,5	2302,0	2376,4	2451,8	2528,3	2605,8	47
48	1944,0	2014,3	2085,3	2157,0	2229,7	2303,2	2377,7	2453,1	2529,6	2607,1	48
49	1945,2	2015,4	2086,5	2158,2	2230,9	2304,4	2378,9	2454,3	2530,8	2608,4	49
50	1946,4	2016,6	2087,7	2159,4	2232,1	2305,7	2380,1	2455,6	2532,1	2609,7	50
51	1947,5	2017,8	2088,9	2160,7	2233,3	2306,9	2381,4	2456,9	2533,4	2611,0	51
52	1948,7	2019,0	2090,1	2161,9	2234,6	2308,1	2382,6	2458,1	2534,7	2612,3	52
53	1949,9	2020,2	2091,3	2163,1	2235,8	2309,4	2383,9	2459,4	2536,0	2613,6	53
54	1951,0	2021,3	2092,5	2164,3	2237,0	2310,6	2385,1	2460,7	2537,2	2614,9	54
55	1952,2	2022,5	2093,7	2165,5	2238,2	2311,8	2386,4	2461,9	2538,5	2616,2	55
56	1953,4	2023,7	2094,9	2166,7	2239,4	2313,1	2387,6	2463,2	2539,8	2617,5	56
57	1954,5	2024,9	2096,1	2167,9	2240,7	2314,3	2388,9	2464,5	2541,1	2618,8	57
58	1955,7	2026,0	2097,3	2169,1	2241,9	2315,5	2390,2	2465,8	2542,4	2620,1	58
59	1956,9	2027,2	2098,5	2170,3	2243,1	2316,7	2391,4	2467,0	2543,7	2621,4	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	30	31	32	33	34	35	36	37	38	39	D. l.

D. l.	40	41	42	43	44	45	46	47	48	49	D.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	2622,7	2701,6	2781,7	2863,1	2945,7	3030,0	3115,6	3202,8	3291,6	3382,1	0
1	2624,0	2702,9	2783,1	2864,5	2947,2	3031,4	3117,0	3204,2	3293,1	3383,6	1
2	2625,3	2704,3	2784,4	2865,8	2948,6	3032,8	3118,5	3205,7	3294,6	3385,2	2
3	2626,6	2705,6	2785,8	2867,2	2950,0	3034,2	3119,9	3207,2	3296,1	3386,7	3
4	2627,9	2706,9	2787,1	2868,5	2951,4	3035,6	3121,4	3208,6	3297,5	3388,2	4
5	2629,2	2708,3	2788,5	2870,0	2952,8	3037,0	3122,8	3210,1	3299,0	3389,7	5
6	2630,5	2709,6	2789,8	2871,3	2954,2	3038,4	3124,2	3211,6	3300,5	3391,3	6
7	2631,9	2710,9	2791,2	2872,7	2955,6	3039,8	3125,7	3213,0	3302,0	3392,8	7
8	2633,2	2712,2	2792,5	2874,1	2957,0	3041,3	3127,1	3214,5	3303,5	3394,3	8
9	2634,5	2713,6	2793,8	2875,4	2958,4	3042,7	3128,6	3216,0	3305,0	3395,9	9
10	2635,	2714,9	2795,1	2876,8	2959,8	3044,1	3130,0	3217,4	3306,5	3397,4	10
11	2637,1	2716,2	2796,5	2878,2	2961,1	3045,5	3131,5	3218,9	3308,0	3398,9	11
12	2638,4	2717,5	2797,9	2879,5	2962,5	3047,0	3132,9	3220,4	3309,5	3400,4	12
13	2639,7	2718,9	2799,3	2880,9	2963,9	3048,4	3134,3	3221,9	3311,0	3402,0	13
14	2641,	2720,2	2800,6	2882,3	2965,3	3049,8	3135,8	3223,3	3312,5	3403,5	14
15	2642,3	2721,5	2802,0	2883,7	2966,7	3051,2	3137,2	3224,8	3314,0	3405,0	15
16	2643,6	2722,9	2803,3	2885,0	2968,1	3052,6	3138,7	3226,3	3315,5	3406,6	16
17	2644,9	2724,2	2804,7	2886,4	2969,5	3054,1	3140,1	3227,7	3317,0	3408,1	17
18	2646,3	2725,5	2806,	2887,8	2970,9	3055,5	3141,6	3229,2	3318,5	3409,6	18
19	2647,6	2726,9	2807,4	2889,2	2972,3	3056,9	3143,0	3230,7	3320,0	3411,2	19
20	2648,9	2728,2	2808,8	2890,5	2973,7	3058,3	3144,5	3232,2	3321,5	3412,7	20
21	2650,2	2729,5	2810,1	2891,9	2975,1	3059,7	3145,9	3233,6	3323,1	3414,2	21
22	2651,	2730,8	2811,4	2893,3	2976,5	3061,2	3147,4	3235,1	3324,6	3415,8	22
23	2652,8	2732,2	2812,8	2894,7	2977,9	3062,6	3148,8	3236,6	3326,1	3417,3	23
24	2654,1	2733,5	2814,1	2896,0	2979,3	3064,0	3150,3	3238,1	3327,6	3418,8	24
25	2655,	2734,8	2815,5	2897,4	2980,7	3065,1	3151,7	3239,5	3329,1	3420,4	25
26	2656,8	2736,2	2816,8	2898,8	2982,1	3066,9	3153,2	3241,0	3330,6	3421,9	26
27	2658,1	2737,5	2818,2	2900,2	2983,5	3068,3	3154,6	3242,5	3332,1	3423,5	27
28	2659,4	2738,8	2819,5	2901,5	2984,9	3069,7	3156,1	3244,0	3333,6	3425,0	28
29	2660,7	2740,2	2820,9	2902,9	2986,3	3071,1	3157,5	3245,5	3335,1	3426,5	29
30	2662,0	2741,5	2822,	2904,3	2987,7	3072,6	3159,0	3246,9	3336,6	3428,1	30
31	2663,3	2742,9	2823,6	2905,7	2989,1	3074,0	3160,4	3248,4	3338,1	3429,6	31
32	2664,6	2744,2	2825,0	2907,1	2990,5	3075,4	3161,9	3249,9	3339,6	3431,2	32
33	2666,0	2745,5	2826,3	2908,4	2991,9	3076,9	3163,3	3251,4	3341,1	3432,7	33
34	2667,3	2746,9	2827,7	2909,7	2993,3	3078,3	3164,8	3252,9	3342,7	3434,2	34
35	2668,6	2748,2	2829,0	2911,2	2994,7	3079,7	3166,2	3254,4	3344,2	3435,8	35
36	2669,9	2749,5	2830,4	2912,6	2996,1	3081,1	3167,7	3255,8	3345,7	3437,3	36
37	2671,2	2750,9	2831,8	2914,0	2997,5	3082,6	3169,1	3257,3	3347,2	3438,9	37
38	2672,5	2752,2	2833,1	2915,3	2998,9	3084,0	3170,6	3258,8	3348,7	3440,4	38
39	2673,9	2753,5	2834,5	2916,7	3000,3	3085,4	3172,1	3260,3	3350,1	3442,0	39
40	2675,1	2754,9	2835,8	2918,1	3001,8	3086,9	3173,5	3261,8	3351,7	3443,5	40
41	2676,5	2756,2	2837,2	2919,5	3003,2	3088,3	3175,0	3263,3	3353,2	3445,0	41
42	2677,8	2757,6	2838,6	2920,9	3004,6	3089,7	3176,4	3264,7	3354,8	3446,6	42
43	2679,1	2758,9	2839,9	2922,3	3006,0	3091,2	3177,9	3266,2	3356,3	3448,1	43
44	2680,5	2760,2	2841,3	2923,6	3007,4	3092,6	3179,3	3267,7	3357,8	3449,7	44
45	2681,8	2761,5	2842,6	2925,0	3008,8	3094,0	3180,8	3269,2	3359,3	3451,2	45
46	2683,1	2762,9	2844,0	2926,4	3010,2	3095,5	3182,3	3270,7	3360,8	3452,8	46
47	2684,4	2764,3	2845,4	2927,8	3011,6	3096,9	3183,7	3272,2	3362,3	3454,3	47
48	2685,7	2765,6	2846,7	2929,2	3013,0	3098,3	3185,2	3273,7	3363,9	3455,9	48
49	2687,1	2766,9	2848,1	2930,6	3014,4	3099,8	3186,6	3275,2	3365,4	3457,4	49
50	2688,4	2768,3	2849,5	2932,0	3015,8	3101,2	3188,1	3276,6	3366,9	3459,0	50
51	2689,7	2769,6	2850,8	2933,3	3017,2	3102,6	3189,6	3278,1	3368,4	3460,5	51
52	2691,0	2771,0	2852,2	2934,7	3018,7	3104,1	3191,0	3279,6	3369,9	3462,1	52
53	2692,3	2772,3	2853,6	2936,1	3020,1	3105,6	3192,5	3281,1	3371,5	3463,6	53
54	2693,7	2773,7	2854,9	2937,5	3021,5	3107,0	3194,0	3282,6	3373,0	3465,2	54
55	2695,0	2775,0	2856,3	2938,9	3022,9	3108,4	3195,4	3284,1	3374,5	3466,7	55
56	2696,3	2776,4	2857,7	2940,3	3024,3	3109,8	3196,9	3285,6	3376,0	3468,3	56
57	2697,6	2777,7	2859,1	2941,7	3025,7	3111,2	3198,4	3287,1	3377,6	3469,8	57
58	2699,0	2779,0	2860,5	2943,1	3027,1	3112,7	3199,8	3288,6	3379,1	3471,4	58
59	2700,3	2780,4	2861,8	2944,4	3028,5	3114,1	3201,3	3290,1	3380,6	3473,0	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	40	41	42	43	44	45	46	47	48	49	D. l.

. l.	50	51	52	53	54	55	56	57	58	59	D. l.
in.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	3474,	3568,8	3665,2	3763,8	3864,7	3968,0	4073,9	4182,6	4294,3	4409,2	0
1	3476,1	3570,4	3666,9	3765,5	3866,4	3969,7	4075,7	4184,5	4296,2	4411,1	1
2	3477,6	3572,0	3668,5	3767,1	3868,1	3971,5	4077,5	4186,3	4298,1	4413,1	2
3	3479,2	3573,6	3670,1	3768,8	3869,8	3973,2	4079,3	4188,2	4300,0	4415,0	3
4	3480,7	3575,2	3671,7	3770,4	3871,5	3975,0	4081,1	4190,0	4301,9	4417,0	4
5	3482,3	3576,8	3673,4	3772,1	3873,2	3976,7	4082,9	4191,8	4303,8	4418,9	5
6	3483,9	3578,4	3675,0	3773,8	3874,9	3978,5	4084,7	4193,7	4305,7	4420,8	6
7	3485,4	3580,0	3676,6	3775,4	3876,6	3980,2	4086,5	4195,5	4307,6	4422,8	7
8	3487,0	3581,6	3678,2	3777,1	3878,3	3982,0	4088,3	4197,4	4309,5	4424,7	8
9	3488,5	3583,2	3679,9	3778,8	3880,0	3983,7	4090,1	4199,2	4311,4	4426,7	9
0	3490,1	3584,8	3681,5	3780,4	3881,7	3985,5	4091,9	4201,1	4313,2	4428,6	10
1	3491,7	3586,4	3683,1	3782,1	3883,4	3987,2	4093,7	4202,9	4315,1	4430,6	11
2	3493,2	3588,0	3684,8	3783,8	3885,1	3989,0	4095,5	4204.7	4317,0	4432,5	12
3	3494,8	3589,5	3686,4	3785,5	3886,8	3990,7	4097,3	4206,6	4318,9	4434,5	13
4	3496,3	3591,1	3688,0	3787,1	3888,6	3992,5	4099,1	4208,4	4320,8	4436,4	14
5	3497,9	3592,7	3689,7	3788,8	3890,3	3994,2	4100,9	4210,3	4322,7	4438,4	15
6	3499,5	3594,3	3691,3	3790,5	3892,0	3996,0	4102,7	4212,1	4324,6	4440,4	16
7	3501,0	3595,9	3692,9	3792,1	3893,7	3997,7	4104,5	4214,0	4326,5	4442,3	17
8	3502,6	3597,5	3694,6	3793,8	3895,4	3999,5	4106,3	4215,8	4328,4	4444,3	18
9	3504,2	3599,1	3696,2	3795,5	3897,1	4001,3	4108,1	4217,7	4330,3	4446,2	19
0	3505,7	3600,7	3697,8	3797,2	3898,8	4003,0	4109,9	4219,5	4332,2	4448,2	20
1	3507,3	3602,3	3699,5	3798,8	3900,5	4004,8	4111,7	4221,4	4334,2	4450,2	21
2	3508,9	3603,9	3701,1	3800,5	3902,3	4006,5	4113,5	4223,2	4336,1	4452,1	22
3	3510,5	3605,5	3702,7	3802,2	3904,0	4008,3	4115,3	4225,1	4338,0	4454,1	23
4	3512,0	3607,1	3704,4	3803 9	3905,7	4010,0	4117,1	4227,0	4339,9	4456,0	24
5	3513,6	3608,7	3706,0	3805,5	3907,4	4011,8	4118,9	4228,8	4341,8	4458,0	25
6	3515,1	3610,3	3707,7	3807,2	3909,1	4013,6	4120,7	4230,7	4343,7	4460,0	26
7	3516,7	3611,9	3709,3	3808,9	3910,9	4015,3	4122,5	4232,5	4345,6	4461,9	27
8	3518,3	3613,6	3710,9	3810,6	3912,6	4017,1	4124,3	4234,4	4347,5	4463,9	28
9	3519,8	3615,2	3712,6	3812,3	3914,3	4018,9	4126,1	4236,2	4349,4	4465,9	29
0	3521,4	3616,8	3714,2	3813,9	3916,0	4020,6	4127,9	4238,1	4351,3	4467,8	30
1	3523,0	3618,4	3715,9	3815,6	3917,7	4022,4	4129,7	4240,0	4353,3	4469,8	31
2	3524,6	3620,0	3717,5	3817,3	3919,5	4024,2	4131,6	4241,8	4355,2	4471,8	32
3	3526,1	3621,6	3719,2	3819,0	3921,2	4025,9	4133,4	4243,7	4357,1	4473,8	33
4	3527,7	3623,2	3720,8	3820,7	3922,9	4027,7	4135,2	4245,6	4359,0	4475,7	34
5	3529,3	3624,8	3722,4	3822,3	3924,6	4029,5	4137,0	4247,4	4360,9	4477,7	35
6	3530,9	3626,4	3724,1	3824,0	3926,4	4031,2	4138,8	4249,3	4362,8	4479,7	36
7	3532,4	3628,0	3725,7	3825,7	3928,1	4033,0	4140,6	4251,2	4364,8	4481,7	37
8	3534,0	3629,6	3727,4	3827,4	3929,8	4034,8	4142,5	4253,0	4366,7	4483,6	38
9	3535,6	3631,3	3729,0	3829,1	3931,5	4036,6	4144,3	4254,9	4368,6	4485,6	39
0	3537,2	3632,9	3730,7	3830,8	3933,3	4038,3	4146,1	4256,8	4370,5	4487,6	40
1	3538,8	3634,5	3732,3	3832,5	3935,0	4040,1	4147,9	4258,6	4372,5	4489,6	41
2	3540,3	3636,1	3734,0	3834,2	3936,7	4041,9	4149,7	4260,5	4374,4	4491,6	42
3	3541,9	3637,7	3735,6	3835,8	3938,5	4043,6	4151,6	4262,4	4376,3	4493,5	43
4	3543,5	3639,3	3737,3	3837,5	3940,2	4045,4	4153,4	4264,3	4378,2	4495,5	44
5	3545,1	3640,9	3738,9	3839,2	3941,9	4047,2	4155,2	4266,1	4380,2	4497,5	45
6	3546,7	3642,5	3740,6	3840,9	3943,7	4049,0	4157,0	4268,0	4382,1	4499,5	46
7	3548,2	3644,2	3742,2	3842,6	3945,4	4050,8	4158,8	4269,9	4384,0	4501,5	47
8	3549,8	3645,8	3743,9	3844,3	3947,1	4052,5	4160,7	4271,8	4385,9	4503,5	48
9	3551,4	3647,4	3745,6	3846,0	3948,9	4054,3	4162,5	4273,6	4387,9	4505,5	49
0	3553,0	3649,0	3747,2	3847,7	3950,6	4056,1	4164,3	4275,5	4389,8	4507,5	50
1	3554,6	3650,6	3748,9	3849,4	3952,3	4057,9	4166,2	4277,4	4391,7	4509,4	51
2	3556,1	3652,3	3750,5	3851,1	3954,1	4059,7	4168,0	4279,3	4393,7	4511,4	52
3	3557,7	3653,9	3752,2	3852,8	3955,8	4061,4	4169,8	4281,1	4395,6	4513,4	53
4	3559,3	3655,5	3753,8	3854,5	3957,6	4063,2	4171,7	4283,0	4397,5	4515,4	54
5	3560,9	3657,1	3755,5	3856,2	3959,3	4065,0	4173,5	4284,9	4399,5	4517,4	55
6	3562,5	3658,7	3757,2	3857,9	3961,0	4066,8	4175,3	4286,8	4401,4	4519,4	56
7	3564,1	3660,4	3758,8	3859,6	3962,8	4068,6	4177,2	4288,7	4403,4	4521,4	57
8	3565,7	3662,0	3760,5	3861,3	3964,5	4070,4	4179,0	4290,6	4405,3	4523,4	58
9	3567,2	3663,6	3762,2	3863,0	3966,3	4072,1	4180,8	4292,5	4407,2	4525,4	59
in.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
l.	50	51	52	53	54	55	56	57	58	59	D. l.

D. l.	60	61	62	63	64	65	66	67	68	69
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.
0	4527,4	4649,2	4775,0	4905,0	5039,4	5178,8	5323,6	5474,0	5630,9	5794,6
1	4529,4	4651,3	4777,1	4907,2	5041,7	5181,2	5326,0	5476,6	5633,5	5797,4
2	4531,4	4653,4	4779,3	4909,4	5044,0	5183,6	5328,5	5479,2	5636,2	5800,2
3	4533,4	4655,5	4781,4	4911,6	5046,3	5186,0	5330,9	5481,7	5638,9	5803,0
4	4535,4	4657,5	4783,5	4913,8	5048,6	5188,3	5333,4	5484,3	5641,	5805,8
5	4537,4	4659,6	4785,7	4916,0	5050,8	5190,7	5335,9	5486,9	5644,2	5808,6
6	4539,4	4661,7	4787,8	4918,2	5053,2	5193,1	5338,3	5489,4	5646,9	5811,4
7	4541,4	4663,7	4790,0	4920,4	5055,5	5195,4	5340,8	5492,0	5649,6	5814,2
8	4543,4	4665,8	4792,1	4922,6	5057,7	5197,8	5343,3	5494,6	5652,3	5817,0
9	4545,4	4667,9	4794,2	4924,8	5060,0	5200,2	5345,7	5497,1	5655,0	5819,8
10	4547,5	4669,9	4796,4	4927,1	5062,3	5202,6	5348,2	5499,7	5657,6	5822,6
11	4549,5	4672,0	4798,5	4929,3	5064,6	5205,0	5350,7	5502,3	5660,3	5825,4
12	4551,5	4674,1	4800,7	4931,5	5066,9	5207,3	5353,2	5504,9	5663,0	5828,2
13	4553,5	4676,2	4802,8	4933,7	5069,2	5209,7	5355,6	5507,4	5665,7	5831,0
14	4555,5	4678,2	4804,9	4935,9	5071,5	5212,1	5358,1	5510,0	5668,4	5833,9
15	4557,5	4680,3	4807,1	4938,1	5073,8	5214,5	5360,6	5512,6	5671,1	5836,7
16	4559,5	4682,4	4809,2	4940,4	5076,1	5216,9	5363,1	5515,2	5673,8	5839,5
17	4561,5	4684,	4811,4	4942,6	5078,4	5219,3	5365,6	5517,8	5676,5	5842,3
18	4563,6	4686,6	4813,5	4944,8	5080,7	5221,7	5368,1	5520,4	5679,2	5845,2
19	4565,6	4688,6	4815,	4947,0	5083,0	5224,1	5370,5	5523,0	5681,9	5848,0
20	4567,6	4690,7	4817,8	4949,3	5085,3	5226,5	5373,0	5525,6	5684,6	5850,8
21	4569,6	4692,8	4820,	4951,5	5087,7	5228,9	5375,5	5528,2	5687,3	5853,7
22	4571,6	4694,9	4822,2	4953,7	5090,0	5231,3	5378,0	5530,8	5690,0	5856,5
23	4573,7	4697,	4824,3	4956,0	5092,3	5233,7	5380,5	5533,4	5692,8	5859,3
24	4575,7	4699,1	4826,5	4958,2	5094,6	5236,1	5383,0	5536,0	5695,5	5862,2
25	4577,7	4701,2	4828,6	4960,4	5096,9	5238,5	5385,5	5538,6	5698,2	5865,0
26	4579,7	4703,2	4830,8	4962,7	5099,2	5240,9	5388,0	5541,2	5700,9	5867,9
27	4581,8	4705,3	4832,9	4964,9	5101,5	5243,3	5390,5	5543,8	5703,6	5870,7
28	4583,8	4707,4	4835,1	4967,1	5103,9	5245,7	5393,0	5546,4	5706,3	5873,5
29	4585,8	4709,5	4837,3	4969,4	5106,2	5248,1	5395,5	5549,0	5709,1	5876,4
30	4587,8	4711,6	4839,4	4971,6	5108,5	5250,5	5398,0	5551,6	5711,8	5879,3
31	4589,9	4713,7	4841,6	4973,9	5110,8	5252,9	5400,5	5554,2	5714,5	5882,1
32	4591,9	4715,8	4843,8	4976,1	5113,1	5255,3	5403,0	5556,8	5717,3	5885,0
33	4593,9	4717,9	4845,9	4978,3	5115,5	5257,7	5405,6	5559,5	5720,0	5887,8
34	4596,0	4720,0	4848,1	4980,6	5117,8	5260,1	5408,1	5562,1	5722,7	5890,7
35	4598,0	4722,1	4850,3	4982,8	5120,1	5262,6	5410,6	5564,7	5725,5	5893,6
36	4600,1	4724,2	4852,5	4985,1	5122,5	5265,0	5413,1	5567,3	5728,2	5896,4
37	4602,1	4726,3	4854,6	4987,3	5124,8	5267,4	5415,6	5569,9	5731,0	5899,3
38	4604,1	4728,4	4856,8	4989,6	5127,1	5269,8	5418,1	5572,6	5733,7	5902,2
39	4606,2	4730,5	4859,0	4991,8	5129,5	5272,3	5420,7	5575,2	5736,4	5905,1
40	4608,2	4732,6	4861,2	4994,1	5131,8	5274,7	5423,2	5577,8	5739,2	5907,9
41	4610,3	4734,7	4863,3	4996,3	5134,1	5277,1	5425,7	5580,5	5741,9	5910,8
42	4612,3	4736,9	4865,5	4998,6	5136,5	5279,5	5428,2	5583,1	5744,7	5913,7
43	4614,3	4739,0	4867,7	5000,9	5138,8	5282,0	5430,8	5585,7	5747,5	5916,6
44	4616,4	4741,1	4869,9	5003,1	5141,2	5284,4	5433,3	5588,4	5750,2	5919,5
45	4618,4	4743,2	4872,1	5005,4	5143,5	5286,8	5435,8	5591,0	5753,0	5922,4
46	4620,5	4745,3	4874,3	5007,6	5145,9	5289,3	5438,4	5593,7	5755,7	5925,2
47	4622,5	4747,4	4876,4	5009,9	5148,2	5291,7	5440,9	5596,3	5758,5	5928,1
48	4624,6	4749,5	4878,6	5012,2	5150,6	5294,2	5443,5	5599,0	5761,3	5931,0
49	4626,6	4751,7	4880,8	5014,4	5152,9	5296,6	5446,0	5601,6	5764,0	5933,9
50	4628,7	4753,8	4882,9	5016,7	5155,3	5299,0	5448,5	5604,3	5766,8	5936,8
51	4630,7	4755,9	4885,2	5019,0	5157,6	5301,5	5451,1	5606,9	5769,6	5939,7
52	4632,8	4758,0	4887,4	5021,2	5160,0	5303,9	5453,6	5609,6	5772,3	5942,6
53	4634,8	4760,1	4889,6	5023,5	5162,3	5306,4	5456,2	5612,2	5775,1	5945,5
54	4636,9	4762,3	4891,8	5025,8	5164,7	5308,8	5458,7	5614,9	5777,9	5948,5
55	4639,0	4764,4	4894,0	5028,1	5167,0	5311,3	5461,3	5617,5	5780,7	5951,4
56	4641,0	4766,5	4896,2	5030,3	5169,4	5313,7	5463,8	5620,2	5783,5	5954,3
57	4643,1	4768,6	4898,4	5032,6	5171,8	5316,2	5466,4	5622,9	5786,2	5957,2
58	4645,1	4770,8	4900,6	5034,9	5174,1	5318,6	5468,9	5625,5	5789,0	5960,1
59	4647,2	4772,9	4902,8	5037,2	5176,5	5321,1	5471,5	5628,2	5791,8	5963,
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.
D. l.	60	61	62	63	64	65	66	67	68	69

D. l.	70	71	72	73	74	75	76	77	78	79	D. l.
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
0	5966,0	6145,7	6334,9	6534,5	6745,7	6970,3	7210,1	7467,2	7744,6	8045,7	0
1	5968,9	6148,8	6338,1	6537,9	6749,4	6974,2	7214,2	7471,7	7749,4	8051,0	1
2	5971,8	6151,9	6341,4	6541,3	6753,0	6978,1	7218,3	7476,1	7754,2	8056,2	2
3	5974,7	6155,0	6344,6	6544,7	6756,6	6981,9	7222,5	7480,6	7759,0	8061,5	3
4	5977,7	6158,0	6347,8	6548,2	6760,3	6985,8	7226,6	7485,0	7763,9	8066,8	4
5	5980,6	6161,1	6351,1	6551,6	6763,9	6989,7	7230,8	7489,5	7768,7	8072,0	5
6	5983,5	6164,2	6354,3	6555,0	6767,6	6993,6	7234,9	7494,0	7773,5	8077,3	6
7	5986,5	6167,3	6357,6	6558,5	6771,2	6997,5	7239,1	7498,5	7778,4	8082,6	7
8	5989,4	6170,4	6360,9	6561,9	6774,9	7001,4	7243,3	7502,9	7783,2	8087,9	8
9	5992,4	6173,5	6364,1	6565,4	6778,5	7005,3	7247,5	7507,4	7788,1	8093,2	9
10	5995,3	6176,6	6367,4	6568,8	6782,2	7009,2	7251,6	7511,9	7793,0	8098,5	10
11	5998,3	6179,7	6370,6	6572,3	6785,8	7013,1	7255,8	7516,4	7797,8	8103,8	11
12	6001,2	6182,8	6373,9	6575,7	6789,5	7017,0	7260,0	7520,9	7802,7	8109,2	12
13	6004,2	6185,9	6377,2	6579,2	6793,2	7020,9	7264,2	7525,4	7807,6	8114,5	13
14	6007,1	6189,0	6380,5	6582,6	6796,9	7024,8	7268,4	7530,0	7812,5	8119,8	14
15	6010,1	6192,1	6383,7	6586,1	6800,5	7028,7	7272,6	7534,5	7817,4	8125,2	15
16	6013,0	6195,2	6387,0	6589,5	6804,2	7032,7	7276,8	7539,0	7822,3	8130,6	16
17	6016,0	6198,3	6390,3	6593,0	6807,9	7036,6	7281,0	7543,6	7827,2	8135,9	17
18	6019,0	6201,4	6393,6	6596,5	6811,6	7040,5	7285,2	7548,1	7832,2	8141,3	18
19	6021,9	6204,6	6396,9	6600,0	6815,3	7044,5	7289,4	7552,7	7837,1	8146,7	19
20	6024,9	6207,7	6400,2	6603,4	6819,0	7048,4	7293,7	7557,2	7842,0	8152,1	20
21	6027,9	6210,8	6403,5	6606,9	6822,7	7052,4	7297,9	7561,8	7847,0	8157,5	21
22	6030,8	6213,9	6406,8	6610,4	6826,4	7056,3	7302,1	7566,3	7841,9	8162,9	22
23	6033,8	6217,1	6410,1	6613,9	6830,1	7060,3	7306,4	7570,9	7856,9	8168,3	23
24	6036,8	6220,2	6413,4	6617,4	6833,8	7064,2	7310,6	7575,5	7861,9	8173,7	24
25	6039,8	6223,3	6416,7	6620,9	6837,6	7068,2	7314,9	7580,1	7866,8	8179,2	25
26	6042,7	6226,5	6420,0	6624,4	6841,3	7072,2	7319,1	7584,7	7871,8	8184,6	26
27	6045,7	6229,6	6423,3	6627,9	6845,0	7076,2	7323,4	7589,3	7876,8	8190,1	27
28	6048,7	6232,7	6426,6	6631,4	6848,7	7080,1	7327,7	7593,9	7881,8	8195,5	28
29	6051,7	6235,9	6429,9	6635,0	6852,5	7084,1	7332,0	7598,5	7886,8	8201,0	29
30	6054,7	6239,0	6433,2	6638,5	6856,2	7088,1	7336,2	7603,1	7891,8	8206,5	30
31	6057,7	6242,2	6436,6	6642,0	6860,0	7092,1	7340,4	7607,7	7896,8	8212,0	31
32	6060,7	6245,3	6439,9	6645,5	6863,7	7096,1	7344,8	7612,3	7901,9	8217,5	32
33	6063,7	6248,5	6443,2	6649,1	6867,5	7100,1	7349,1	7617,0	7906,9	8223,0	33
34	6066,7	6251,7	6446,6	6652,6	6871,2	7104,1	7353,4	7621,6	7911,9	8228,5	34
35	6069,7	6254,8	6449,9	6656,1	6875,0	7108,2	7357,7	7626,3	7917,0	8234,1	35
36	6072,7	6258,0	6453,3	6659,7	6878,7	7112,2	7362,0	7630,9	7922,1	8239,6	36
37	6075,7	6261,2	6456,6	6663,2	6882,5	7116,2	7366,4	7635,6	7927,1	8245,1	37
38	6078,8	6264,4	6460,0	6666,8	6886,3	7120,2	7370,7	7640,2	7932,2	8250,7	38
39	6081,8	6267,5	6463,3	6670,3	6890,1	7124,3	7375,0	7644,9	7937,3	8256,3	39
40	6084,8	6270,7	6466,7	6673,9	6893,8	7128,3	7379,4	7649,6	7942,4	8261,8	40
41	6087,8	6273,9	6470,0	6677,4	6897,6	7132,3	7383,7	7654,3	7947,5	8267,4	41
42	6090,8	6277,1	6473,4	6681,0	6901,4	7136,4	7388,0	7659,0	7952,6	8273,0	42
43	6093,9	6280,3	6476,8	6684,6	6905,2	7140,4	7392,4	7663,7	7957,7	8278,6	43
44	6096,9	6283,5	6480,1	6688,1	6909,0	7144,5	7396,8	7668,4	7962,8	8284,2	44
45	6099,0	6286,6	6483,5	6691,7	6912,8	7148,6	7401,1	7673,1	7968,0	8289,9	45
46	6103,0	6289,8	6486,9	6695,3	6916,6	7152,6	7405,5	7677,8	7973,1	8295,5	46
47	6106,0	6293,0	6490,3	6698,9	6920,4	7156,7	7409,9	7682,6	7978,2	8301,1	47
48	6109,1	6296,2	6493,6	6702,4	6924,2	7160,8	7414,2	7687,3	7983,4	8306,8	48
49	6112,1	6299,4	6497,0	6706,0	6928,1	7164,9	7418,6	7692,0	7988,5	8312,4	49
50	6115,1	6302,7	6500,4	6709,6	6931,9	7169,0	7423,0	7696,8	7993,7	8318,1	50
51	6118,2	6305,9	6503,8	6713,2	6935,7	7173,0	7427,4	7701,5	7998,9	8323,8	51
52	6121,2	6309,1	6507,2	6716,8	6939,5	7177,1	7431,8	7706,3	8004,0	8329,4	52
53	6124,3	6312,3	6510,6	6720,4	6943,4	7181,2	7436,2	7711,0	8009,2	8335,1	53
54	6127,4	6315,5	6514,0	6724,0	6947,2	7185,3	7440,6	7715,8	8014,4	8340,8	54
55	6130,4	6318,7	6517,4	6727,6	6951,1	7189,5	7445,0	7720,6	8019,6	8346,6	55
56	6133,5	6322,0	6520,8	6731,2	6954,9	7193,6	7449,5	7725,4	8024,8	8352,3	56
57	6136,5	6325,2	6524,2	6734,9	6958,8	7197,7	7453,9	7730,2	8030,0	8358,0	57
58	6139,6	6328,4	6527,6	6738,5	6962,6	7201,8	7458,3	7735,0	8035,3	8363,7	58
59	6142,7	6331,7	6531,0	6742,1	6966,5	7205,9	7462,8	7739,8	8040,5	8369,5	59
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	min.
D. l.	70	71	72	73	74	75	76	77	78	79	D. l.

D. l.	80	81	82	83	84	85	86	87	88	89
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.
0	8375,3	8739,1	9145,5	9605,9	10137,0	10764,7	11532,6	12522,3	13916,6	16299,8
1	8381,0	8745,5	9152,7	9614,1	10146,6	10776,2	11547,0	12541,4	13945,4	16357,5
2	8386,8	8751,9	9159,9	9622,4	10156,2	10787,7	11561,4	12560,7	13974,4	16416,3
3	8392,6	8758,3	9167,2	9630,6	10165,8	10799,3	11575,9	12580,0	14003,7	16476,1
4	8398,3	8764,8	9174,4	9638,9	10175,4	10810,0	11590,5	12599,5	14033,2	16537,0
5	8404,1	8771,2	9181,6	9647,2	10185,1	10822,6	11605,0	12619,1	14063,0	16594,9
6	8409,9	8777,7	9188,9	9655,5	10194,8	10834,2	11619,7	12638,8	14093,0	16662,0
7	8415,8	8784,1	9196,2	9663,8	10204,6	10845,9	11634,5	12658,6	14123,3	16726,2
8	8421,6	8790,6	9203,5	9672,2	10214,4	10857,7	11649,3	12678,6	14153,9	16791,7
9	8427,4	8797,1	9210,8	9680,6	10224,2	10869,6	11664,1	12698,6	14184,7	16858,5
10	8433,3	8803,6	9218,1	9689,0	10234,0	10881,4	11679,1	12718,8	14215,8	16926,5
11	8439,1	8810,1	9225,4	9697,4	10243,8	10893,3	11694,0	12739,1	14247,2	16990,0
12	8445,0	8816,6	9232,7	9705,8	10253,7	10905,2	11709,1	12759,5	14278,9	17066,9
13	8450,9	8823,2	9240,2	9714,2	10263,6	10917,2	11724,2	12780,0	14310,9	17130,3
14	8456,8	8829,7	9247,6	9722,7	10273,5	10929,1	11739,4	12800,7	14343,2	17213,2
15	8462,6	8836,3	9255,0	9731,2	10283,5	10941,2	11754,7	12821,3	14375,8	17288,7
16	8468,6	8842,8	9262,4	9739,7	10293,5	10953,3	11770,0	12842,5	14408,7	17366,0
17	8474,5	8849,4	9269,9	9748,3	10303,5	10965,5	11785,4	12863,5	14441,9	17444,0
18	8480,4	8856,0	9277,3	9756,8	10313,6	10977,7	11800,9	12884,7	14475,4	17525,9
19	8486,3	8862,6	9284,8	9765,4	10323,7	10989,9	11816,4	12906,0	14509,3	17608,7
20	8492,3	8869,3	9292,3	9774,0	10333,8	11002,2	11832,0	12927,4	14543,5	17693,6
21	8498,2	8875,9	9299,8	9782,7	10344,0	11014,5	11847,6	12948,9	14578,1	17780,5
22	8504,2	8882,6	9307,3	9791,3	10354,1	11026,9	11863,4	12970,6	14613,0	17879,9
23	8510,2	8889,2	9314,8	9800,0	10364,3	11039,3	11879,2	12992,5	14648,3	17961,6
24	8516,2	8895,9	9322,4	9808,6	10374,5	11051,7	11895,1	13014,4	14683,9	18055,8
25	8522,2	8902,6	9330,0	9817,3	10384,8	11064,2	11911,0	13036,6	14719,9	18152,6
26	8528,2	8909,3	9337,6	9826,1	10395,0	11076,8	11927,1	13058,8	14756,3	18252,3
27	8534,2	8916,0	9345,2	9834,8	10405,3	11089,3	11943,1	13081,2	14793,0	18354,9
28	8540,2	8922,7	9352,8	9843,6	10415,7	11102,0	11959,3	13103,8	14830,2	18460,7
29	8546,2	8929,5	9360,4	9852,4	10426,2	11114,6	11975,6	13126,5	14867,8	18569,8
30	8552,3	8936,2	9368,1	9861,3	10436,6	11127,4	11991,9	13149,3	14905,8	18682,5
31	8558,4	8943,0	9375,8	9870,1	10447,1	11140,1	12008,4	13172,3	14944,2	18799,1
32	8564,4	8949,8	9383,5	9879,0	10457,5	11152,9	12024,9	13195,[illegible]	14983,0	18919,7
33	8570,5	8956,6	9391,2	9887,8	10468,0	11165,8	12041,5	13218,8	15022,3	19044,7
34	8576,6	8963,4	9398,9	9896,7	10478,5	11178,7	12058,2	13242,3	15062,1	19174,4
35	8582,7	8970,2	9406,6	9905,7	10489,1	11191,7	12074,9	13265,9	15102,3	19309,2
36	8588,9	8977,1	9414,4	9914,6	10499,7	11204,7	12091,7	13289,7	15143,0	19449,[illegible]
37	8595,0	8983,9	9422,1	9923,6	10510,4	11217,7	12108,6	13313,7	15184,2	19595,8
38	8601,1	8990,8	9429,9	9932,7	10521,1	11230,8	12125,6	13337,8	15225,8	19748,6
39	8607,3	8997,7	9437,8	9941,7	10531,8	11244,0	12142,7	13362,1	15268,0	19908,5
40	8613,5	9004,6	9445,6	9950,8	10542,6	11257,2	12159,9	13386,6	15310,7	20076,4
41	8619,6	9011,5	9453,4	9959,8	10553,3	11270,5	12177,1	13411,2	15353,8	20252,5
42	8625,8	9018,4	9461,3	9968,9	10564,1	11283,8	12194,4	13436,1	15397,8	20483,3
43	8632,0	9025,4	9469,1	9978,0	10574,9	11297,1	12211,8	13461,1	15442,1	20635,1
44	8638,2	9032,3	9477,0	9987,2	10585,8	11310,5	12229,3	13486,3	15486,9	20843,5
45	8644,5	9039,3	9484,9	9996,3	10596,7	11324,0	12246,9	13511,6	15532,6	21065,4
46	8650,7	9046,3	9492,9	10005,5	10607,6	11337,6	12264,6	13537,0	15578,7	21302,5
47	8656,9	9053,3	9500,8	10014,8	10618,6	11351,1	12282,4	13562,8	15625,5	21557,3
48	8663,2	9060,3	9508,8	10024,0	10629,7	11364,8	12300,2	13588,9	15672,7	21832,5
49	8669,5	9067,3	9516,8	10033,3	10640,8	11378,4	12318,1	13615,1	15721,0	22131,6
50	8675,7	9074,4	9524,8	10042,6	10651,9	11392,2	12336,3	13641,4	15769,8	22459,3
51	8682,0	9081,4	9532,9	10051,9	10663,0	11406,0	12354,4	13667,8	15819,3	22821,5
52	8688,3	9088,5	9540,9	10061,3	10674,1	11419,8	12372,7	13694,5	15869,4	23226,4
53	8694,6	9095,6	9548,9	10070,6	10685,3	11433,7	12391,0	13721,5	15920,4	23685,4
54	8701,0	9102,7	9557,0	10080,0	10696,5	11447,7	12409,5	13748,9	15972,1	24215,3
55	8707,3	9109,8	9565,1	10089,4	10707,7	11461,7	12428,0	13776,1	16024,6	24842,1
56	8713,6	9116,9	9573,2	10098,9	10719,1	11475,8	12446,5	13803,7	16077,9	25609,2
57	8720,0	9124,0	9581,4	10108,4	10730,4	11489,9	12465,3	13831,5	16132,0	26[illegible]98,2
58	8726,4	9131,2	9589,5	10117,9	10741,8	11504,1	12484,2	13859,6	16187,0	27992,1
59	8732,7	9138,4	9597,7	10127,4	10753,3	11518,3	12503,1	13887,8	16242,9	30375,0
min.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M. P.	M.	M. P.	M. P.
D. l.	80	81	82	83	84	85	86	87	88	89

THE ELEMENTS OF NAVIGATION.

BOOK VIII.

OF ASTRONOMY.

SECTION I.

Of Solar Aſtronomy.

28. ASTRONOMY is a ſcience which treats of the motions and diſtances of the heavenly bodies, and of the appearances ence ariſing.

There have been a great variety of opinions among the philoſophers of e preceding ages concerning the diſpoſition of the great bodies in the iverſe, or of the poſitions of the bodies which appear in the heavens: ut the notion now embraced by the moſt judicious aſtronomers, is, at the univerſe is compoſed of an infinite number of ſyſtems or worlds; every ſyſtem there are certain bodies moving in free ſpace, and relving at different diſtances around a SUN placed in or near the centre the ſyſtem; and that theſe *ſuns* and other bodies are the ſtars which e ſeen in the heavens.

829. That ſyſtem in which our earth is placed, is by aſtronomers lled the SOLAR SYSTEM; and herein the notion of the ſun being fixed or near the centre, with ſeveral bodies revolving round him at diffent diſtances, is confirmed by all the obſervations hitherto made: This inion is called the COPERNICAN SYSTEM; from *Nicholas Copernicus*,

a Poliſh philoſopher, who about the year 1473 revived this notion from the oblivion it had been buried in for many ages.

Stars are diſtinguiſhed into two kinds, namely, *fixed* and *wandering.*

830. The FIXED STARS are the ſuns in the centres of their ſyſtem ſhining by their own light; and which are obſerved to preſerve alway the ſame ſituations in reſpect to one another.

831. The fixed ſtars appear of various ſizes, doubtleſs occaſioned b their different diſtances; theſe ſizes are uſually diſtinguiſhed into ſix o ſeven claſſes, called Magnitudes: The largeſt, or brighteſt, are ſaid t be of the FIRST MAGNITUDE; thoſe in the next claſs, or degree o brightneſs, are called of the SECOND MAGNITUDE; and ſo on to th leaſt, or thoſe juſt diſcernible to the naked eye: But beſide theſe, ther are ſcattered throughout the heavens a great number of other ſtars, calle TELESCOPIC STARS, they being only to be ſeen through that inſtrument. And indeed, it is to the aſſiſtance of that moſt admirable machine, that a great part of the modern aſtronomy owes its riſe, an which will undoubtedly tranſmit, with the greateſt honour to the lateſ poſterity, the name of GALILEO, among whoſe many inventions th teleſcope is to be ranked.

832. Altho' the viſible fixed ſtars are probably at very unequal diſtances from the centre of the *ſolar ſyſtem*, yet aſtronomers, for thei eaſe of computation, reckon them as tho' they were all equally diſtan from our ſun, forming the ſurface of a ſphere incloſing our ſyſtem, an called the CELESTIAL SPHERE: Which ſuppoſition may be ſtrictl admitted, conſidering the immenſe diſtance of even the neareſt of th fixed ſtars.

833. A CONSTELLATION is a number of ſtars lying in the neighbourhood of one another on the ſurface of the *celeſtial ſphere*, and whicl aſtronomers, for their eaſy remembrance, ſuppoſe to be circumſcribed b the outlines of ſome *animal*, or other *figure*; whereby the motions o the wandering ſtars are more readily deſcribed and compared.

The number of theſe conſtellations are 80, each containing ſevera ſtars of different magnitudes: The number of ſtars of each magnitude and alſo the conſtellation wherein they are ranged, are contained in th following table; where it may be obſerved, that the conſtellations ar diſtinguiſhed under three heads, namely, in the *zodiac*, and in the northern and ſouthern hemiſpheres.

834. CONSTELLATIONS IN THE ZODIAC.

Names. Northern.	Number	Magnitudes I	II	III	IV	V	VI	Names. Southern.	Number	Magnitudes I	II	III	IV	V	V
Aries	46	0	1	1	3	5	36	Libra	33	0	2	1	8	3	1
Taurus	109	1	1	3	9	24	71	Scorpio	44	1	3	6	14	5	1
Gemini	94	1	2	4	8	13	66	Sagittarius	48	0	1	5	9	[illegible]	2
Cancer	75	0	0	0	6	8	61	Capricornus	58	0	0	2	5	9	4
Leo	91	2	2	6	13	11	57	Aquarius	93	0	0	4	7	8	[illegible]
Virgo	93	1	0	5	11	24	52	Piſces	110	0	0	1	7	8	7

835. NOR

135. NORTHERN CONSTELLATIONS.

Names	Number	Magnitudes I	II	III	IV	V	VI	Names	Number	Magnitudes I	II	III	IV	V	VI
Little Bear	12	0	2	1	4	3	2	Camelopardalus	23	0	0	0	5	7	11
Great Bear	105	0	5	5	16	30	49	Serpent	50	0	1	7	6	5	31
Dragon	49	0	1	7	8	10	23	Serpentarius	67	0	1	6	12	17	31
Cepheus	40	0	0	3	7	10	20	Sobieſki's Shield	8	0	0	0	2	3	3
Greyhounds	24	0	0	0	1	7	16	Eagle	29	1	0	5	1	4	18
Bootes	53	1	0	7	10	12	23	Antinous	34	0	0	5	2	7	20
Mons Mænalus	11	0	0	0	1	0	10	Dolphin	18	0	0	6	0	2	10
Berenice's Hair	24	0	0	0	6	8	10	Colt	12	0	0	0	4	1	7
Charles's Heart	3	0	1	0	0	0	2	Arrow	13	0	0	0	4	1	8
Northern Crown	11	0	1	0	6	3	1	Andromeda	66	0	3	2	10	16	35
Hercules	92	0	0	12	12	28	40	Perſeus	67	1	1	5	10	14	36
Cerberus	9	0	0	0	3	1	5	Pegaſus	81	0	3	4	9	11	54
Harp	24	1	0	3	2	8	10	Auriga	46	1	1	1	9	9	25
Swan	73	0	1	5	15	20	32	Lynx	55	0	0	1	8	21	25
Fox	29	0	0	0	6	11	12	Little Lion	20	0	0	1	6	5	8
Gooſe	10	0	0	0	0	2	8	Great Triangle	10	0	0	0	3	1	6
Lizard	12	0	0	0	3	5	4	Little Triangle	5	0	0	0	0	0	5
Caſſiopeia	52	0	0	5	7	7	33	Muſca	6	0	0	1	2	2	1

36. SOUTHERN CONSTELLATIONS.

Names	Number	Magnitudes I	II	III	IV	V	VI	Names	Number	Magnitudes I	II	III	IV	V	VI
Whale	80	0	2	8	13	10	47	Peacock	14	0	1	3	5	4	1
Eridanus	72	1	0	10	24	19	18	Southern Crown	12	0	0	0	1	3	8
Phenix	13	0	1	5	5	0	2	Crane	14	0	2	1	2	9	0
American Gooſe	9	0	0	4	2	3	0	Southern Fiſh	15	1	0	2	9	2	1
Orion	93	2	4	3	19	15	50	Hare	25	0	0	4	9	4	8
Monoceros	32	0	0	1	10	10	11	Noah's Dove	10	0	2	0	1	6	1
Little Dog	14	1	0	1	0	2	10	Charles's Oak	13	0	1	2	6	4	0
Hydra	53	0	1	3	14	13	22	Ship Argo	48	1	6	11	13	14	3
Sextan's Uraniæ	4	0	0	0	0	0	4	Great Dog	29	1	5	1	4	10	8
Cup	11	0	0	0	8	2	1	Bee	4	0	0	0	2	2	0
Crow	8	0	0	2	2	2	2	Swallow	11	0	0	0	4	3	4
Centaur	36	2	6	6	14	8	0	Indus	12	0	0	0	4	6	2
Wolf	36	0	0	3	6	18	9	Chamelion	10	0	0	0	0	9	1
Altar	9	0	0	1	6	1	1	Flying Fiſh	7	0	0	0	0	6	1
Southern Triangle	5	0	1	2	0	2	0	Sword Fiſh	7	0	0	2	2	1	2

	Stars	I	II	III	IV	V	VI
Conſtellations in the zodiac 12, contains	894	6	12	38	100	169	569
Northern conſtellations 36, contains	1243	5	21	92	200	291	634
Southern conſtellations 32, contains	706	9	32	75	185	188	217
Number of ſtars in the 80 conſtellations	2843	20	65	205	485	648	1420

As theſe ſtars are found not to alter their ſituation in reſpect to one nother, they ſerve aſtronomers as fixed points, whereby the motions of other bodies may be compared; and therefore their relative poſition have with great care been ſought after for many ages, and catalogues o the obſervations have from time to time been publiſhed by thoſe wh have been at the pains to make them: Among theſe catalogues, the mo copious, and, as generally eſteemed, the beſt, is that called the *Hiſtori Celeſtis* of FLAMSTEED.

837. The poſitions of the ſtars being obtained, their relative place may be delineated on a ſphere or plane, as well as the parts of the earth by knowing their latitudes and longitudes (662); and thus are the map or charts of the heavens made, and the conſtellations drawn, incloſing their reſpective ſtars. There are two maps, uſually called Celeſtial hemiſpheres, made by *Senex*, and *others*, that are to be had in many places by the help whereof, a perſon may readily become acquainted with th poſitions and names of ſome of the principal fixed ſtars, thus.

On a clear night, let theſe prints be laid ſo as to correſpond to th north and ſouth parts of the heavens; then the obſerver ſometimes looking on the ſtars and then on the hemiſpheres, will with a little practic know ſome of the ſtars in the heavens, whoſe like poſitions and name he has obſerved on the prints.

838. The WANDERING STARS are thoſe bodies within our ſyſte or celeſtial ſphere, which revolve round the ſun; they appear luminou or bright, only by reflecting the light they receive from the ſun, and are of three kinds, namely, *primary planets*, *ſecondary planets*, and *comets*.

839. The PRIMARY PLANETS are thoſe bodies which, in revolving round the ſun, reſpect him only as the centre of their courſes; wherein their motions are regularly performed in tracks or paths, that are, by obſervations found to be, nearly circular and concentric to one another.

840. A SECONDARY PLANET, commonly called a SATELLITE or MOON, is a body which, while it is carried round the ſun, does alſo revolve round a primary planet which it reſpects as its centre.

841. COMETS, vulgarly called *Blazing ſtars*, are bodies which alſo revolve round the ſun; probably in as regular order as the planets: Their appearances near the ſun are very ſeldom; they are in number about 40, and their tracks or courſes paſs among the paths of the planets in a great variety of directions.

842. The ORBIT of a planet or comet is that track or path along which it moves.

There are ſix *primary planets*, which reckoned in order from the ſun, their names and marks are MERCURY ☿, VENUS ♀, the EARTH ♁ or ⊖, MARS ♂, JUPITER ♃, SATURN ♄.

Mars, *Jupiter*, and *Saturn*, are called SUPERIOR PLANETS, as their orbits include that of the *Earth*: But *Venus* and *Mercury*, whoſe orbits are contained within the *Earth*'s, are called INFERIOR PLANETS.

843. There are found, by obſervations with teleſcopes, to be ten *ſecondary planets*; the Earth is attended by one called the MOON, Jupiter by four, and Saturn by five.

Saturn is alſo obſerved to have a kind of circle, called his RING, which ſurrounds the planet at ſome diſtance from his ſurface: And Jupiter er has certain appearances, which ſeem like zones or girdles round n; and theſe are called JUPITER's BELTS.

Every primary planet is ſuppoſed to have two motions, namely, *annl* and *diurnal*.

344. The ANNUAL MOTION of a planet is that whereby the planet scarried in its orbit round the ſun; which in every one is found by ervation to be from weſt to eaſt.

This motion is diſcovered by the planets changing their places in the eſtial ſphere, upon whoſe ſurface they appear to move among the ed ſtars; and in certain times return to the ſame ſtars from whence y were ſeen to depart; and ſo on continually.

45. The DIURNAL MOTION of a planet is that by which it turns ſpins about its axis, and is alſo from weſt to eaſt.

This motion is diſcovered by the ſpots that are ſeen by teleſcopes on ſurfaces of the planets: Theſe ſpots appear firſt on the eaſtern mari, or ſide of the planet, and gradually move from thence acroſs it, till y diſappear on the weſtern ſide, or *limb*; and after a certain time apr again on the eaſtern ſide, and ſo on.

46. Each planet is obſerved always to paſs thro' the conſtellations *s*, *Taurus*, *Gemini*, *Cancer*, *Leo*, *Virgo*, *Libra*, *Scorpio*, *Sagittarius*, *ricornus*, *Aquarius*, *Piſces*; and it alſo appears that every one has a k peculiar to itſelf; whereby, the paths of the ſix planets form among ſtars a kind of road, which is called the ZODIAC, the middle path reof, called the ECLIPTIC, is the orbit deſcribed by the Earth, with ch the orbits of the other planets are compared.

s the ecliptic runs thro' twelve conſtellations, it is ſuppoſed to be ided into twelve equal parts, of 30 degrees each, called ſigns, having ſame names with the twelve conſtellations they run thro'.

47. The *Plane of the Ecliptic* is ſuppoſed to divide the celeſtial ſphere two equal parts, called the *northern* and *ſouthern celeſtial hemiſpheres*; any body in either of theſe hemiſpheres is ſaid to have north or n latitude, according to the hemiſphere it is in: So that the LATIDE of a celeſtial object is its neareſt diſtance from the ecliptic.

he Planes of the other five orbits are obſerved to lie partly in the hern and partly in the ſouthern hemiſphere; ſo that every one cuts ecliptic in two oppoſite points, called NODES: One called the ENDING NODE, is that thro' which the planet paſſes when it moves of the ſouthern into the northern hemiſphere; and the other called DESCENDING NODE, is that thro' which the planet muſt paſs in g out of the northern into the ſouthern hemiſphere.

he right line joining the two nodes of any planet, is called the LINE THE NODES.

8. The names to moſt of the conſtellations were given by the ani aſtronomers, who reckoned that ſtar in Aries, now marked γ, (acng to *Bayer*) to be the firſt point in the ecliptic, this ſtar being the ſun when he entered the *Vernal equinox* (633); and at that each conſtellation was in the ſign by which it was called: But obtions ſhew, that the point marked in the heavens by the *Vernal ox* has been conſtantly going backwards by a ſmall quantity every whereby the ſtars appear to have advanced as much forwards; ſo

that the conſtellation *Aries* is now almoſt removed into the ſign *Ta* the ſaid firſt ſtar γ being got almoſt 30 degrees forwards from the nox; which difference is called the PRECESSION OF THE EQUINO whereof the yearly alteration is about 50 ſeconds of a degree, or a a degree in 72 years.

849. It was ſaid in art. 839, that the planets revolved round the in orbits nearly circular and concentric; for the ſeveral phænor ariſing from their motions ſhew they are not ſtrictly ſo; and the curve they can move in, to reconcile all the various appearance found to be an ELLIPSIS (vulgarly called an *oval*): Which is a c that cannot like the circle be deſcribed on a plane from one ce but requires two; about which two, if there be moved a ſtret doubled thread, whereof each of the two folds is longer than th ſtance of the two centres, the bight or loop of the thread will by motion deſcribe the curve called the ELLIPSIS. The cloſer the ce pins are brought together, the nearer will the ellipſe approach circle; ſo that when the centres coincide, then a circle will be deſcr by the motion of the thread.

The two centres of the ellipſe are called FOCUS's: A right line dr thro' the two focus's, and terminated at each end by the curve, is c the *Tranſverſe*, or *longer diameter*: Another right line, drawn at angles to the *tranſverſe diameter* thro' its middle, and terminated by curve, is called the *Conjugate diameter*: The interſection of the diameters is called the *Centre of the ellipſe*; and the diſtance of centre from either focus is called the EXCENTRICITY.

850. All the planets have one common focus, in which the ſu placed: For as no other ſuppoſition can ſolve all the appearances tha obſerved in the motion of the planets, and as it alſo agrees with ſtricteſt phyſical and mathematical reaſoning; therefore it is now ceived as an elementary principle.

851. The Line of the nodes of every planet paſſes thro' the ſun: as the motion of every planet is in a plane paſſing thro' the ſun, ſequently the interſections of theſe planes, that is the lines of the no muſt alſo paſs thro' the ſun.

852. All the planets in their revolutions are ſometimes nearer, ſo times farther from the ſun: This is a conſequence of the ſun not ing placed in the centre of each orbit, and they being ellipſes.

853. The APHELION, or SUPERIOR APSIS, is that point of orbit where the planet is fartheſt from the ſun: And the PERIHELI or INFERIOR APSIS, is that point where it is neareſt the ſun: And tranſverſe diameter of the orbit, or the line joining the two apſes called the LINE OF THE APSES, or APSIDES.

854. The planets move faſter as they approach the ſun, or c nearer to the perihelion, and ſlower as they recede from the ſun come nearer the aphelion: This is not only a conſequence from the ture of the planets motions about the ſun, but is confirmed by all g obſervations.

855. If a right line drawn from the ſun thro' any planet, and ca by ſome the *Vector radius*, be ſuppoſed to revolve round the ſun the planet, then this line will deſcribe or paſs thro' every part of

p

ne of the orbit; ſo that the *vector radius* may be ſaid to deſcribe the a of the orbit.

856. There are two *chief laws* obſerved in the ſolar ſyſtem which gulate the motions of all the planets; namely,

I. *The planets deſcribe equal areas in equal times:* That is, in equal portions of time the *vector radius* deſcribes equal areas or portions of the ſpace contained within the planet's orbit.

II. *The ſquares of the periodical times of the planets are as the cubes of their mean diſtances from the ſun:* That is, the ſquare of the time which a planet A takes to revolve in its orbit, is to the ſquare of the time taken by any other planet B to run thro' its orbit; ſo is the cube of the mean diſtance of A from the ſun, to the cube of the mean diſtance of B from the ſun.

57. The MEAN DISTANCE of a planet from the ſun, is its diſtance from him when the planet is at either extremity of the conjugate diameter; and is equal to half the tranſverſe diameter.

58. The foregoing laws are the two famous laws of KEPLER, a great aſtronomer, who flouriſhed in Germany about the beginning of the 17th century, and who deduced them from a multitude of obſervations: But the firſt who demonſtrated theſe laws was the incomparable Sir ISAAC NEWTON.

By the ſecond law, the relative diſtances of the planets from the ſun are known; and was the real diſtance of any one known, the abſolute diſtances of all the others would thereby be obtained.

59. Every thing already ſaid of the planets, is found in a great meaſure to be applicable alſo to the comets, as well from the obſervations that have been made of them, as from the phyſical and mathematical conſiderations of their motions.

60. Was the motions of the planets to be obſerved from the ſun, each of them would be ever ſeen to move the ſame way, though with different velocities; thoſe nearer the ſun running their courſes thro' the zodiac in leſs time than thoſe at greater diſtances: And hence it would happen, that ſome of them overtaking of the others would, in their paſſing by them, appear to be ſometimes above, ſometimes below, and ſometimes as if they touched one another, according to the parts of the orbits thoſe planets happened to be in with reſpect to their nodes.

61. When two planets are ſeen together in the ſame ſign equally advanced therein, they are ſaid to be in CONJUNCTION: But when they are in direct oppoſite parts of the zodiac, they are ſaid to be in OPPOSITION.

62. As the planes of the orbits are inclined to one another, therefore when two planets happen to be in conjunction at the time they come near their nodes, they would be ſeen from the ſun apparently to touch one another; and the fartheſt of thoſe planets from the ſun would for ſome time have its light obſcured by the nearer planet, it being then directly between the ſun and the remoter planet. Alſo, ſhould an oppoſition of two planets happen near their nodes, the ſun being then di-

rectly between them, would hide the light of one from the other. theſe obſcurations, or interceptions of the light of the planets one f the other, are called **Eclipses.**

863. The place that any planet appears to occupy in the cele ſphere, when ſeen by an obſerver ſuppoſed in the ſun, is called its *H* *ocentric place:* And indeed all celeſtial appearances, as ſeen from the are called *Heliocentric phænomena.*

864. The following table exhibits at once ſome of the moſt m rial concluſions that have been deduced from the obſervations hith made, the mean diſtance of the earth from the ſun being reckone 1000.

Table of the Solar system.

Planets Names	Marks	Mean diſt. compared to that of the earth	Eccentricity	Inclination of the orbits to the eclipt.	Times of the periodical revolutions	Diurnal rotations	True diameters
Mercury	☿	387	81	6° 52′	3 m. or 87^d 23^h	uncertain	0,32
Venus	♀	724	5	3 23	8 m. or 224 17	23^h 0^m 0^s	0,87
Earth	♁	1000	17	0 00	1 y. or 365 6	23 56 4	1,00
Mars	♂	1524	141	1 52	2 y. or 686 23	24 40 0	0,73
Jupiter	♃	5201	250	1 20	12 y. or 4232 12	9 56 0	7,70
Saturn	♄	9538	543	2 20	30 y. or 10759 8	uncertain	4,19

865. By all the obſervations made on the ſecondary planets, it pears,

1ſt. That the ſatellites revolve round their ſuperior planets from v to eaſt, in curve lined orbits like ellipſes, the primary planet being the focus, and one of the orbit's diameters directed towards the ſun.

2d. The planes of the ſatellites orbits are inclined to the plane their reſpective planet's orbit.

3d. That, like the primary planets, they deſcribe equal areas in e times; and the ſquares of the times of their revolutions are as the c of the diſtances from their primary planet.

As the orbits of the ſecondary planets ſurround their primary, th fore in every revolution of a moon it muſt, in reſpect to its prim and the ſun, be twice in conjunction, and may be eclipſed in eit caſe, according as the moon's nodes happen to be poſited at thoſe tim For the planes of a moon's orbit is inclined to that of its primary, ſo makes two nodes; in whoſe line, whenever the ſun, planet moon happen at the ſame time, there muſt be an eclipſe; which wo occur at every conjunction, but for the inclination of the orbit.

One of the conjunctions, namely that made by the moon's going yond the primary, is called the Superior conjunction; and other, made by the ſatellite on that ſide of the planet next the ſun, called the Inferior conjunction.

The following table ſhews the times taken by each ſatellite in its re- ution; and alſo its diſtance from the primary in ſemidiameters there- o.

	I	II	III	IV	V
	d h m	d h m	d h m	d h m	d h m
rn's ſatellites	1 21 18$\frac{1}{2}$	2 17 41$\frac{1}{3}$	4 12 25$\frac{1}{5}$	15 22 41$\frac{1}{4}$	79 7 48
D. from Saturn	8$\frac{7}{8}$ ſ. diam.	11$\frac{1}{4}$ ſ.diam	15 ſ. diam.	36 ſ. diam.	108 ſ.diam.
iter's ſatellites	1 18 28$\frac{3}{5}$	3 13 18$\frac{5}{6}$	7 3 59$\frac{2}{3}$	16 18 5$\frac{1}{10}$	
D. from Jupiter	5$\frac{2}{3}$ ſ. diam.	9 ſ. diam	14$\frac{1}{3}$ ſ. diam.	25$\frac{1}{3}$ ſ. diam.	
T: Moon	29 12 44$\frac{1}{20}$	and is diſt. from the earth 60$\frac{1}{5}$ ſemidiameters.			

7. *Of the figure and light of the Planets.*

hat the ſun and planets are ſpherical bodies, is evident from all the rvations that have been made of them; and that the earth is of like re, is not only deduced by analogy, but ſufficiently confirmed by rvation (553, 713). Now altho' aſtronomers generally ſay that the ets are ſpherical, yet they do not mean a Geometrical ſphere, but gure called an oblate-ſpheroid, which is ſomething like the figure a flexible ſphere would be formed into by gently preſſing it at its s: Obſervations have determined this in Jupiter, and it is known the earth is of this figure both from obſervations and actual menſu- on.

hat the planets muſt have this oblate figure, is evident from this ſideration; that as they are of matter, and violently whirled on their , all the parts would endeavour to fly off, like water from a trundled , thoſe in the equator moving ſwifteſt, have the greateſt ten- cy to depart: And altho' the parts are retained in the ſphere by the rior force of gravity, yet the equatorial diameters will be ſomewhat eaſed, and the polar leſſened.

68. The planets are all opake or dark bodies, and conſequently e only by the light they receive from the ſun: This is known, by rving that thoſe bodies are not viſible when they are in ſuch parts of r orbits as are between the ſun and earth, or partly ſo. Now as he planets appear with a ſtrong light, therefore the rays they re- e from the ſun muſt convey to them a degree of warmth proporti- in ſome meaſure to their diſtance, which is reciprocally as the res of the diſtances, and this muſt be readily inferred from the heat ch the inhabitants of the earth receive from the ſun.

69. As a planet revolves on its axis, every part of its ſurface will urned towards the ſun, and thereby enjoy its light and heat.

SECTION II.

Of Terreſtrial Aſtronomy.

870. The motions deſcribed in the preceding ſection were ſuc would appear to an obſerver viewing the heavens from the ſun: was he placed in one of the planets, ſuppoſe the Earth, and there ſerved the motions of the reſt, it would appear to him that the ſun, other planets, revolved round the earth as a centre; but the ſun w be the only one that moved uniformly the ſame way: For the c planets would ſeem to move ſometimes from weſt to eaſt, and the ſtand ſtill; then they would ſeem to run from eaſt to weſt, and ſtanding ſome time they would again move from weſt to eaſt, ar on continually.

871. The place in the celeſtial ſphere that any planet appears in, v ſeen from the centre of the earth, is called its GEOCENTRIC PLA

872. The DIRECT MOTION of a planet is that by which it ap to move from weſt to eaſt, and this motion is ſaid to be *according t order of the ſigns*, or in *conſequentia*. When the planet appears to ſtill, it is ſaid to be STATIONARY; and when its motion is a rently from eaſt to weſt, it is then called RETROGRADE, or h motion in *antecedentia*, or contrary to the order of the ſigns. T different appearances follow partly in conſequence of the obſerver b himſelf in motion while he is viewing thoſe of the planets, and p becauſe he is not in the centre of the motions which he obſerves.

873. *The phenomena of the Inferior planets.* See Fig. 1. Plate

Let ABC repreſent an arc of the celeſtial ſphere; EOP the earth' bit; LNIG the orbit of an inferior planet, as of *Venus*; and S the Let the earth at firſt be ſuppoſed to ſtand ſtill in its orbit at E: No is evident that the ſun will appear at the point B, and the planet al within the arc AC. Whilſt the planet moves in its orbit from I Q to N, it will ſeem to move from B to A in *conſequentia*: But pa from N to L, it will ſeem to an eye at E to return back from A or be *retrograde*. While the planet is at or near the point N, being twixt moving on from B to A, and returning from A to B, and mo as it were in a right line towards the earth, it will for ſome time to ſtand ſtill near A, that is, to be *ſtationary*.

874. When the planet is in that part of her orbit N or G, whic contiguous to the tangent EA or EC, ſhe will then appear at A o her greateſt diſtance from the ſun, and is ſaid to be in her greateſ LONGATION: This elongation is meaſured by the angle SEG. more diſtant a planet is from the ſun, the greater will its angle of e gation be; that of Venus is about 48 degrees, and of Mercury a 28 degrees.

In the ſpace of a revolution, the two inferior planets will with re to the earth, undergo two conjunctions; one when it is beyond the ſ I, the other when it is at L between the ſun and the earth; the fo is called the *ſuperior*, and the latter the *inferior conjunction*.

875. Whilſt Venus goes from her ſuperior conjunction ſhe appears in t arc AB, always to the eaſtward of the ſun, and therefore ſets ſome t e after the ſun, and is called the *evening ſtar:* But during the time ſ is going from her inferior to her ſuperior conjunction, ſhe will be ſn ſomewhere in the arc BC to the weſtward of the ſun, and ſo will ſet ore him in the evening, and riſe before him in the morning; hence ſ is called the *morning ſtar.*

Hitherto the planet only has been ſuppoſed to move while the earth ſod ſtill: But when both move, the foregoing phenomena will be much t ſame, only the planet will be more direct in the fartheſt part of the oit, and leſs retrograde; the former ariſing from the ſum of their tions, and the latter from the difference.

86. *Of the phenomena of the Superior planets.*

The *direct*, *ſtationary* and *retrograde* motions of the ſuperior planets a explained much after the ſame manner as thoſe of the inferior ones, with theſe differences.

1ſt. The retrograde motions of the ſuperior planets happen oftner the ver their motions are, as the retrogradations of the inferior planets hpen oftner the ſwifter their angular motions: Becauſe the retrograde tions of the ſuperior planets depend upon the motions of the earth, thoſe of the inferior on their own angular motions. A ſuperior net is retrograde once in each revolution of the earth, an inferior one every revolution of its own.

2d. The ſuperior planets do not always accompany the ſun as the erior do, but are often in oppoſition; which neceſſarily follows from orbit of the earth being included within the orbits of the ſuperior nets.

87. *Of the apparent Motion of the Sun.*

As a ſpectator in the ſun would ſee the earth revolve thro' the ſigns the ecliptic, ſo to a ſpectator in the earth, the ſun apparently revolves ſame way, but is always in the oppoſite point of the ecliptic: (For s well known to every one, eſpecially to thoſe who uſe the ſea, that d objects appear to change their place by the motion of the obſerver): that the heliocentric place of the earth, and the geocentric place of ſun, are always in direct oppoſite points of the ecliptic.

Now altho' it is the motion of the earth that really cauſes a great iety in the apparent motions of the other planets; yet as that of the being known, gives that of the earth, therefore it is that aſtronos ſpeak of the motion of the ſun, and in their computations uſe the ntities of thoſe motions as if they were real.

78. Beſide the various appearances that ariſe from the annual motion the earth, there are many reſulting from its diurnal motion: For t the earth has a daily motion round its axis, muſt neceſſarily be ined from the moſt ſtrict reaſoning on the motions of the planets: Bes the notion of bodies, ſo immenſly diſtant as are the ſtars, really olving round the earth in 24 hours, is now treated as a great ab-

ſurdity by every one who has rightly conſidered theſe things: Howe as the motions are apparent, and the ſpeaking of them as real is cu mary, and no way affecting the concluſions; therefore aſtronomers t of theſe motions as they appear.

879. Any ſphere revolving as on an axis, muſt have two points or ſurface, at the extremities of its axis, that do not revolve at all; t points, with reſpect to the earth, are called its *poles*.

880. By the earth's rotation on its axis from weſt to eaſt in a c the ſurface of the celeſtial ſphere appears to move from eaſt to weſ the ſame time; and all the celeſtal objects appear to deſcribe circle the heavens, which are greater or leſs, according as they are farther fr or nearer to, the apparent centres of thoſe motions: For there are points in the heavens which are apparently fixed, and the nearer ſtars are to theſe points, the ſlower are their motions. Theſe points called the CELESTIAL POLES; the right line joining them is ca the AXIS OF THE SPHERE, and paſſes thro' the poles of the ea That circle in the heavens, equally diſtant from the poles of the cele ſphere, is called the EQUINOCTIAL; the correſponding circle on earth is called the EQUATOR, which is equally diſtant from both poles.

881. As the ſun's rays falling on any ſphere enlightens one hal its ſurface; therefore one half of the earth is always illuminated at o and conſequently the enlightned part is bounded by a great circle, wh may be called the TERMINATOR, from its property of terminat or bounding the verges of light and darkneſs: Now by the rotatio the earth on its axis once in 24 hours, there will be a conſtant ſucceſ of light in all parts as they are turned towards the ſun, and of dark in theſe parts as they move out of his rays; and hence ariſe the vic tudes of DAY and NIGHT.

882. Did the plane of the equator coincide with the plane of ecliptic, and the axis of the earth ſtand perpendicular to it, the ter nator would always paſs thro' the poles of the earth, and there wo be a conſtant equality of day and night in every part of its ſurface, cept at the two poles, where there would be conſtant day: But the c trary of this is known to every one, and obſervations ſhew that earth's axis is inclined to the plane of the ecliptic in an angle of ab 66½ degrees; therefore the poles of the ecliptic and equator are about degrees diſtant from one another; conſequently the ecliptic and equin tial, which in the heavens interſect one another in the oppoſite poin Aries and Libra, make at thoſe interſections angles of about 23½ grees (413): This angle is called the OBLIQUITY OF THE ECL TIC.

The axis of the earth being thus inclined to the plane of the eclip and moving parallel to itſelf in all points of the ANNUAL ORBIT, ecliptic, is the occaſion of the inequalities of days and nights, and the different ſeaſons of the year; which two phenomena are explai as follows.

883. It muſt be obſerved, that the ſun will appear to be vertical that part of the earth, which is cut by a ſtrait line joining the cen of the ſun and earth.

884. Now when the earth is at ♑, the ſun appearing then in ♋, will be vertical to that point of the terreſtrial ecliptic, it lying in the right line joining the centres of the ſun and earth: And this point being in the earth's northern hemiſphere, all thoſe who live therein will enjoy ſummer, or the hotteſt time of the year, the ſolar rays falling more copiouſly, and more perpendicularly upon their hemiſphere at that time. Fig. 3. Pl. IX.

885. At the ſame time the inhabitants of the ſouthern hemiſphere will have winter, the rays of the ſun falling more obliquely, and in leſs quantity on them, and conſequently affording them leſs heat.

886. Again, the inhabitants of the northern hemiſphere will have their days longer than their nights, in proportion as they are more diſtant from the equator; whilſt thoſe who live under the equator will have an equal ſhare of day and night all the year round: For in this poſition the *terminator*, which is always at right angles to the plane of the ecliptic, will paſs 23½ degrees beyond the north pole, and conſequently will cut all the circles parallel to the equator, it meets with, into two unequal parts, the greater portion being in the enlightned hemiſphere: But the terminator being a great circle, will cut the equator into two equal parts; therefore half the equator is always illuminated.

887. Hence it neceſſarily follows, that thoſe who live under the equator will have their days and nights equal: The inhabitants of the north *temperate zone* (567) will have their nights ſhorter than their days; while thoſe who live in the north *frigid zone* enjoy perpetual day. In the mean time, thoſe who live in the ſouthern hemiſphere have their nights longer than their days, in proportion as they approach nearer the ſouth pole; and thoſe contained within the ſouth frigid zone will have conſtant night.

888. Suppoſe the earth now to move in its orbit from ♑ thro' the ſigns ♒, ♓ to ♈, and the ſun will ſeem to run thro' the ſigns ♌, ♍ to ♎; and this will be the place of the ſun in autumn.

While the earth is in ♈, the days and nights will be equal in both hemiſpheres, and the ſeaſon is a medium between ſummer and winter: For at that time the ſun will appear vertical to the equator, becauſe a right line joining the centres of the ſun and earth will then cut the ſurface of the earth in the equator; ſo that the *terminator*, whoſe plane is always at right angles to the ſaid line, will paſs thro' the poles; conſequently, all the earth will then have an equal ſhare of day and night. And becauſe the rays of the ſun then fall perpendicularly upon the axis of the earth, it will follow, that they muſt fall with an equal obliquity, and in equal number upon either hemiſphere; therefore they muſt enjoy an equal degree of heat and cold.

Now ſuppoſe the earth to move from ♈ to ♋, and the ſun will ſeem to move from ♎ to ♑, where it will be in its neareſt approach to the ſouth pole; and at this time of the year it will be winter in the northern hemiſphere. For to this hemiſphere the like phenomena will now happen, as did before to the ſouthern, when the earth was in ♑; and by a parity of reaſon, when the earth has got as far as ♎, and the ſun is apparently in ♈, the northern hemiſphere will enjoy ſpring, and the ſouthern will have autumn.

889.

889. The four points of the ecliptic, wherein the earth has be confidered in ſummer, autumn, winter and ſpring, are called the fo CARDINAL POINTS: ♑ and ♋ are called SOLSTITIAL POINTS; ♎ ar ♈, EQUINOCTIAL POINTS.

890. The firſt point of Cancer is called the SUMMER SOLSTICE becauſe when the ſun enters it, which is about the 21ſt of June, he then got to his greateſt extent northwards, and being about to retu towards the equator, he ſeems for a day or two to be at a ſtand. Ar for the ſame reaſon, the firſt point of Capricorn, which the ſun ente about the 21ſt of December, is called the WINTER SOLSTICE, wi reſpect to the northern hemiſphere.

891. The firſt points of Aries and Libra are called the VERNA and AUTUMNAL EQUINOCTIAL POINTS, from the equality of da and nights all over the ſurface of the earth, when the ſun enters tho points,

892. *Of the Riſing and Setting of the Stars.*

There is only one half of the celeſtial ſphere viſible at one time any obſerver on the ſurface of the earth, the other half being hid b the earth itſelf: Now the apparent plane on which the obſerver ſtand ſeems to be extended to, and cuts the heavens, and there marks out circle that divides the viſible from the inviſible hemiſphere; this circ is called the HORIZON, above which all the celeſtial motions are ſee When this horizon is a great circle of the celeſtial ſphere, it is called th RATIONAL HORIZON: But when by the particular ſituation of the ob ſerver, he ſees more or leſs than half the celeſtial ſphere, then th circle bounding his view is called the SENSIBLE HORIZON.

The horizon is one of the moſt uſeful circles in aſtronomy, for t this circle, which is the only apparent one, almoſt all the celeſti motions are referred. It is the common termination of day and night it marks out the times of the riſing and ſetting of the ſun and ſtar and many other particulars, of which hereafter.

893. *Of Parallaxes.*

The parallax of any object is the difference between the places it referred to in the celeſtial ſphere, when ſeen at the ſame time from tw different places within that ſphere: Or, it is the angle under which an two places in the inferior orbits are ſeen from a ſuperior planet, or eve from the fixed ſtars: But the parallaxes uſed by aſtronomers are tho ariſing from ſeeing the object from the centres of the earth and ſun from the ſurface and centre of the earth; and from all three com pounded.

894. The difference between the heliocentric and geocentric place a planet, is called the parallax of the annual orbit (namely that of th earth); that is, the angle at any planet, ſubtended by the diſtance be tween the ſun and earth, is called the parallax of the earth's, or annu orbit.

895. The difference in the two longitudes is called the parallax longitude; and that of the two latitudes, is called the parallax of l titude. 9

896. In the SIZYGIES, that is, in the *oppoſitions* or *conjunctions*, the ſun and planet being either equally advanced in the ſame ſign, or in like places in oppoſite ſigns, the parallax of latitude is then greateſt.

897. And when the planet is in its QUADRATURES, that is, when it is 90 degrees diſtant from the ſun, the parallax of longitude is then the greateſt.

898. To explain the parallaxes which reſpect the earth only. Fig. 2. Plate IX.

Let HSW repreſent the earth, where T is the centre; ORG part of the moon's orbit, P *r g* part of a planet's orbit, and Z *a* A part of a great circle in the celeſtial ſphere: Now to a ſpectator at S upon the ſurface of the earth, let the moon appear in G, that is, in the ſenſible horizon of S, and it will be referred to A; but if viewed from the centre T, it will be referred to the point D, which is its true place.

The arc AD will be the moon's parallax; the angle SGT the parallactic angle: Or the parallax is expreſſed by the angle under which the emidiameter TS of the earth is ſeen from the moon.

If the parallax be conſidered with reſpect to different planets, it will be greater or leſs, as thoſe objects are more or leſs diſtant from the arth. Thus the parallax AD of G is greater than the parallax A *d* of *g*. f it be conſidered with reſpect to the ſame planet, it is evident that the orizontal parallax (or the parallax when the object is in the horizon) s greateſt of all; and diminiſhes gradually as the body riſes above the orizon, until it comes to the zenith, where the parallax vaniſhes, or ecomes equal to nothing. Thus AD and A *d*, the horizontal parallaxes of G and *g*, are greater than *a* B and *a b*, the parallaxes of R and ; and the objects O or P, ſeen from S or T, appear in the ſame place , or the zenith.

899. By knowing the parallax of any celeſtial object, its diſtance om the centre of the earth may be eaſily obtained by Trigonometry. hus if the diſtance of G from T be ſought; in the triangle STG, the de ST being known, and the angle SGT determined by obſervation, the de TG is thence known.

The parallax of the moon may be determined by two perſons obſerving her from different ſtations at the ſame time, ſhe being vertical to e one, and horizontal to the other; and it is generally concluded to e about 57 minutes of a degree; conſequently her diſtance TG is about 0 ſemidiameters of the earth, or 60 times TS.

But the parallax the moſt wanted, is that of the ſun, which if well btained would give the diſtance of all the reſt; and from a tranſit of enus over the ſun's diſk or face, which will happen on the 26th of lay, 1761, the diſtance of the centres of the ſun and earth may be etermined to within a 500th part of the whole, as has been ſhewn y the excellent Dr. Halley.

00. *Of the Meaſure of the Earth.*

The relative diſtances of the planets are diſcovered by the 2d *Keplean law*, and their relative magnitudes are gathered from the angles hich they appear under (when viewed with very accurate inſtruments)

compounded with their diſtances: Now as theſe diſtances and magnitu
can by means of the parallaxes be compared with the diameter of t
earth, conſequently this diameter being accurately known, would ſe
as a meaſure wherewith the magnitudes and diſtances of all the ot
planets might be compared.

To find the meaſure of the earth is a problem of ſuch importance
aſtronomy, that it has been attempted by ſome of the moſt conſidera
men in almoſt all the preceding ages: But its ſolution was not broug
to any degree of accuracy till the year 1635, when it was happily p
fected by our countryman Richard Norwood, an eminent math
matician at that time. The principle he proceeded upon was, that
360 degrees were contained in every great circle, both of the celeſt
ſphere and of the earth, and that theſe circles being conſidered as co
centric to the centre of the earth; therefore was the meaſure of t
length known on a great circle of the earth, correſponding to one
more degrees of a great circle of the heavens, then, by analogy, t
whole circumference of a great circle of the earth would be known
that meaſure, and conſequently its diameter would be obtained. (27

Norwood ſolved this problem in the following manner: He ch
two diſtant places which were known to lie nearly north and ſouth o
of the other, as London and York; and by the method of Trave
ſailing he found their difference of latitude, or the diſtance between t
parallels of latitude paſſing thro' thoſe places; or which is the ſame thi
the length of that arc of the terreſtrial meridian: He alſo with a go
inſtrument found the diſtance between the zeniths of thoſe places, a
conſequently he thence knew the quantity of the celeſtial arc anſweri
to the meaſured terreſtrial one: Then ſaying, As that celeſtial arc, is
a great circle of the celeſtial ſphere, or 360 degrees; ſo is the arc of t
terreſtrial great circle meaſured in feet, to the circumference of a gre
circle on the earth, in feet meaſure.

And thus he found that about 69½ Engliſh miles anſwered to one d
gree; whereby the circumference of the earth appears to be 25020 mil
and its diameter about 8000 miles.

901. *Of the Moon.*

The moon revolves in her orbit from weſt to eaſt round the eart
and with it is carried perpetually thro' the annual orbit round the ſu
making in the ſpace of one year 13 *periodical*, and 12 *ſynodical revol*
tions.

902. A Periodical month, or revolution, is the time t
moon takes up in revolving from one point of her orbit to the ſame poi
again, and conſiſts of 27 d. 7 h. 43 m.

903. A Synodical month, or revolution, is the time t
moon ſpends in paſſing from one conjunction with the ſun to anoth
which is 29 d. 12 h. 44 m.; being 2 d. 5 h. 1 m. longer than the *P*
riodical month: For whilſt the moon is paſſing from her former conjun
tion with the ſun round to it again, the earth has proceeded forwar
in its annual courſe, as it were leaving the moon behind it; ſo that,

on

rder to compleat her next conjunction with the ſun, ſhe muſt not only ome round to her former point again, but alſo go beyond it.

904. Beſides this monthly motion of the moon round the earth, ſhe as alſo a motion round her axis, which is performed exactly in the ame time with her periodical revolution: From whence it comes to aſs, that the ſame face of the moon is always turned towards the earth, er diurnal motion turning juſt as much of her face to us, as her peri-dical from us.

905. Tho' the ſame ſide of the moon be ever turned towards us, yet is not always viſible, but daily ſeems to put on different appearances, lled PHASES: For the moon being an opake body like the reſt of the anets, it borrows its light from the ſun, having always one hemiſphere lightned by the ſolar rays.

When the enlightned hemiſphere is wholly turned from the earth, as her change, the planet then being betwixt us and the ſun, the moon's hole enlightned face or *diſk* muſt needs be inviſible to the earth. hen paſſing from this ſtate, and turning ſome little portion of the uminated half to us, it muſt appear horned, the CUSPS or points be-g turned from the ſun towards the eaſt. When the moon is in her adratures, or at 90 degrees from the ſun, then half the illuminated ce becomes viſible: She afterwards continues to ſhew more than half e enlightned diſk, until ſhe comes in oppoſition to the ſun, when the hole of the illumined orb is preſented to us; from whence receding, e muſt put on the like phaſes as before, but in an inverſe order, the ſps being now turned towards the weſt.

06. *Of ſolar and lunar Eclipſes.*

Eclipſes of the ſun and moon can only happen about the times of the njunctions and oppoſitions: Thoſe of the ſun fall out at the conjunc-ons, when the moon intercepts the light of the ſun from the earth; d thoſe of the moon occur in the oppoſitions, when the earth getting tween the ſun and moon, the latter loſes her light during the time of at interpoſition.

The reaſon why there is not an eclipſe in every ſyzigie is, becauſe the inclination of the plane of the moon's orbit to that of the eclip-t, which is about 5° 18′: For it is certain, that unleſs the ſun, earth d moon be all in the plane of the ecliptic, or nearly ſo, the ſhadows the earth and moon can never fall on one another, but muſt be di-rected either above or below. Now they can never be in the ſame ne, and in one right line, but when the moon is in her nodes, and e nodes and ſun's centre are in the ſame right line.

907. The ſolar and lunar eclipſes do not happen every year in the ne places of the zodiac, but in ſucceeding years, they fall in places adually removed backwards, or towards the antecedent ſigns: For ce the nodes are found to go continually backwards, the eclipſes muſt o obſerve the ſame order.

908. Eclipſes of the moon are either *total* or *partial*: The partial are her *central*; that is, when the node happens to be exactly in the ntre of the ſhadow; or *excentrical*, when the node happens to be on her ſide the centre, within or without the ſhadow. Now the longer

the duration is of a partial eclipſe, ſo much the greater is that part the moon which enters into the ſhadow of the earth.

909. Hence it is uſual to conceive the moon's diameter as divided i 12 parts, called DIGITS, by which the greatneſs of partial eclipſes measured, they being ſaid to be of ſo many digits as there are parts vered by the earth's ſhadow: Thus if 5 of the 12 parts are covered, is called an eclipſe of 5 digits.

910. As the planet Mars is never eclipſed by the Earth, it is pl the ſhadow of the latter does not reach ſo far as the orbit of the f mer, but tapers to a point at a leſs diſtance; and conſequently the eart ſhadow muſt be a cone, whoſe vertex is extended beyond the orbit the moon. It naturally follows from hence, that the ſun is a mu larger body than the earth.

911. If a perſon was placed juſt at the vertex, or point of this ſl dow, he would ſee nothing of the ſun but a ſmall rim of light rou his diſk; and the farther the obſerver was removed from the vertex, larger would the rim of light appear, and conſequently the fewer r would be intercepted by the opake body, till at laſt it would appear o as a ſpot in the ſun; in like manner as the planets Venus and Merc appear when they are ſeen to paſs over the ſun's diſk.

912. What has hitherto been ſaid of the ſhadow, includes that of atmoſphere ſurrounding the earth; for in lunar eclipſes, the ſhadow of t atmoſphere is to be conſidered: And hence it is that the moon is viſible eclipſes, the ſhadow caſt by the atmoſphere being not near ſo dark as tl caſt by the earth.

913. The moon always enters the weſtern ſide of the ſhadow w her eaſtern limb, and quits it with her weſtern limb; and in her a proach to, and receſs from the ſhadow, ſhe muſt paſs thro' a PENU BRA, or imperfect ſhade, which is cauſed by the earth itſelf.

914. In the ſame manner, in which it has been ſhewn that the mo muſt come into the ſhadow of the atmoſphere when ſhe is at full, a at or near a node, it may alſo be ſhewn that her ſhadow muſt fall up the earth at the time of new moon, provided ſhe be in or near a nod But the penumbra of the moon's ſhadow is much more ſenſible ſolar eclipſes, than that accompanying the ſhadow of the earth in lun ones.

915. It is obſerved, that to determinate parts of the earth, ſolar eclip do not happen ſo oft as lunar ones, which is owing to the ſhadow the moon being leſs than that of the earth; for the earth's ſhadow oft covers all the moon, but that of the moon cannot cover all the eart and as it ſometimes falls on one part, ſometimes on another, it cau ſolar eclipſes in general to be more frequent than lunar ones; yet to a determinate place on the earth, there are more eclipſes of the moon vi ble, than of the ſun.

What has hitherto been ſaid, may ſuffice to give beginners a gener idea of the motions of the bodies in the ſolar ſyſtem, and of ſome of t phenomena thence ariſing; thoſe who deſire to be farther acquainted wi particulars, may find them fully treated of in M. le Caille's Elemen of Aſtronomy, publiſhed in Engliſh a few years ſince.

SECTION III.

The Aſtronomy of the ſphere.

6. *Definitions* and *Principles.*

By the Aſtronomy of the ſphere, is meant the finding, from proper tings given, the meaſure of certain arcs and angles formed on the ſur-es of the celeſtial and terreſtrial ſpheres, by the apparent motions of e bodies which are ſeen in the heavens.

The ſurfaces of thoſe ſpheres are ſuppoſed to be concentric to the cen-t of the earth, and to have correſpondent circles deſcribed on both ieres.

917. **GREAT CIRCLES** are thoſe which divide either ſphere into two ual parts.

LESSER CIRCLES, thoſe which divide either into unequal parts.

The **POLES** of a circle are thoſe points on the ſphere equally diſtant m that circle.

An **AXIS** is a right line ſuppoſed to connect the poles.

The **CELESTIAL AXIS** is that right line about which the heavens m to revolve.

The **NORTH** and **SOUTH POLES** of the world are thoſe two points ere the axis cuts the celeſtial ſphere.

918. The **EQUINOCTIAL**, or **EQUATOR**, is that great circle of the ere equally diſtant from the poles of the world.

919. **MERIDIANS**, or **HOUR CIRCLES**, or **CIRCLES OF RIGHT ASNSION**, or **CIRCLES OF TERRESTRIAL LONGITUDE**, are great cirs perpendicular to the equator, and paſſing thro' the poles of the rld.

920. The **ECLIPTIC** is a great circle inclined to the equator in an angle about 23½°, and cutting it in two points diametrically oppoſite.

The ecliptic is ſuppoſed to be divided into 12 equal parts, called **SIGNS**, inning from one of its interſections with the equator; each ſign coning 30 degrees, named and noted thus.

ries	*Taurus*	*Gemini*	*Cancer*	*Leo*	*Virgo*
♈	♉	♊	♋	♌	♍
ibra	*Scorpio*	*Sagittarius*	*Capricornus*	*Aquarius*	*Piſces*
♎	♏	♐	♑	♒	♓

921. The firſt ſix are called *northern*, and the latter ſix *ſouthern* ſigns.

The **CARDINAL POINTS** of the ecliptic are the four firſt points of the is ♈, ♋, ♎, ♑; thoſe of ♈ and ♎ are called **EQUINOCTIAL NTS**, and thoſe of ♋ and ♑ are called **SOLSTITIAL POINTS**.

922. The **EQUINOCTIAL COLURE** is a meridian paſſing thro' the inoctial points; and the **SOLSTITIAL COLURE** is another meridian ing thro' the *ſolſtitial points*. The colures cut one another at right les in the poles of the world.

923. **CIRCLES OF CELESTIAL LONGITUDE** are great circles perpenlar to the ecliptic.

924. The **LATITUDE** of any point in the heavens is an arc of a le of longitude intercepted between that point and the ecliptic, and

is called north or ſouth latitude, as the point is on the north or ſou ſide of the ecliptic.

925. PARALLELS OF CELESTIAL LATITUDE are ſmall circles p rallel to the ecliptic.

926. The LONGITUDE of any point in the heavens is an arc of tl ecliptic intercepted between the firſt point of Aries and a circle of lo gitude paſſing thro' that point.

927. The RIGHT ASCENSION of any point of the celeſtial ſphere an arc of the equator, contained between the firſt point of Aries and meridian paſſing thro' that point: Or, it is the angle formed by the equ noctial colure, and the meridian paſſing over that point.

928. The DECLINATION of any point, is an arc of a meridian co tained between that point and the equinoctial: If the point is on th north ſide of the equinoctial, it is called *north declination*; but if on tl ſouth ſide, it is called *ſouth declination.*

929. The OBLIQUITY OF THE ECLIPTIC is the angle made by tl interſection of the equator and ecliptic, and is meaſured by the ſun greateſt declination; which, according to the modern obſervations, about 23° 28½′, but is uſually reckoned at 23° 29′.

930. PARALLELS OF DECLINATION are ſmall circles parallel to tl equinoctial. The TROPIC OF CANCER is a parallel of declination 23° 29′ diſtant from the equinoctial in the northern hemiſphere; ar the TROPIC OF CAPRICORN is that parallel of declination as far diſta in the ſouthern hemiſphere.

931. The ARTIC POLAR CIRCLE is a parallel of declination at 2 29′ diſtant from the north pole; and the ANTARTIC POLAR CIRCLE that parallel of declination as far diſtant from the ſouth pole.

932. The ZENITH is that point of the heavens directly over a place and the NADIR is the point directly underneath.

933. The HORIZON is that great circle of the ſphere which is equall diſtant from the *zenith* and *nadir* of any place, and divides the ſphe into the upper and lower hemiſpheres.

934. The RISING of a celeſtial object, is when its centre appears i the eaſtern part of the horizon; and its SETTING, is when its centr diſappears in the weſtern quarters of the horizon.

935. AZIMUTH, or VERTICAL CIRCLES, are great circles perpen dicular to the horizon, paſſing thro' its poles, which are the *zenith* an *nadir.*

936. The PRIME VERTICAL is that vertical circle which paſſes thr the eaſt and weſt points of the horizon, and is at right angles to th *meridian of the place*, which is a vertical circle paſſing thro' the nort and ſouth points of the horizon.

937. As the meridian of a place is called the *twelve o'clock hour circl* ſo the hour circle at right angles to the meridian is called the *ſix o'clo hour circle.*

938. The AZIMUTH of any celeſtial object, is an angle at the zenit formed by the meridian of any place, and a vertical circle paſſing thr that object when it is above the horizon: Or, it is meaſured by the ar of the horizon intercepted between thoſe vertical circles.

93

939. The AMPLITUDE of any point in the heavens, is an arc of the rizon contained between that point at its riſing or ſetting, and the terſection of the meridian of the place with the horizon: Or, it is e angle at the zenith included between the meridian of a place and a rtical circle paſſing thro' the point at its riſing or ſetting.

940. The ALTITUDE of any point in the heavens, is an arc of a rtical circle intercepted between that point and the horizon.

941. The ZENITH DISTANCE of any object, is an arc of a vertical rcle contained between that point and the zenith.

The altitude and zenith diſtance are complements one of the other.

942. The MERIDIAN ALTITUDE, or MERIDIAN ZENITH DI- ANCE, is the altitude or zenith diſtance when the object is on the eridian of the place.

943. The CULMINATING of any celeſtial object, is the time it *anſits*, or comes to the meridian.

944. ALMICANTHERS, or PARALLELS OF ALTITUDE, are ſmall rcles parallel to the horizon.

945. A PARALLEL SPHERE, is that poſition of the ſphere wherein e circles, apparently deſcribed by the diurnal rotation, are parallel to e horizon; which can happen only at the poles.

946. A RIGHT SPHERE, is that wherein the diurnal motions are at ht angles to the horizon: Thus it appears in all places under the uator.

947. An OBLIQUE SPHERE has all the diurnal motions oblique to the rizon: And thus the motions appear to all parts of the earth, except der the poles and equator.

948. DIURNAL ARCS, are thoſe parts of the parallels of declination celeſtial objects apparently deſcribed between the times of the riſing d ſetting of thoſe objects: And NOCTURNAL ARCS, are the parts of oſe parallels apparently deſcribed from the time of ſetting to the time riſing.

949. SEMI-DIURNAL and SEMI-NOCTURNAL ARCS, or the halves diurnal and nocturnal arcs, are the parts of the parallels between the eridian and their interſection with the horizon. The correſponding t of the equator anſwering to the ſemi-diurnal arc, gives the time ween noon and the riſing or ſetting; and the equatorial part anſwer- to the ſemi-nocturnal arc, ſhews the time between midnight and e time of ſetting or riſing.

950. The OBLIQUE ASCENSION of any point in the heavens, is the gree of the equator which riſes with that point in an oblique ſphere: d the OBLIQUE DESCENSION, is the degree which ſets with that nt.

951. The ASCENSIONAL DIFFERENCE belonging to any celeſtial ob- t, is the difference between its *right* and *oblique aſcenſions*. In the , it is the time that he riſes or ſets before or after the hour of ſix.

952. The LATITUDE of any place on the earth, is an arc of a ter- rial meridian contained between that place and the equator; being th or ſouth, according to the ſide of the equator it is on.

953. The LONGITUDE of any place on the earth, is an arc of the ator contained between the meridian of that place and the meridian

which is choſe for the firſt, where the reckoning of longitude begin Or, it is the angle at the pole formed by the firſt meridian, and that the place.

954. Refraction, in an aſtronomical ſenſe, is the difference b tween the true and apparent altitudes of an object: For the atmoſphe ſurrounding the earth (602), cauſes all celeſtial objects to appear mo elevated above the horizon than they really are.

955. The Twilight is that medium between light and darkne which happens in the morning before ſun-riſe, and in the evening aft ſun-ſet.

This is occaſioned by the atmoſphere's refracting the ſolar rays up any place, altho' the ſun is below the horizon of that place; and obſervation it is found to begin and end at about 18° below the horizo

956. The Crepusculum is a ſmall circle parallel to the horizon 18° below it, where the twilight begins and ends.

957. The Latitude of a place is expreſſed by an arc of the m ridian, ſhewing the diſtance between the zenith of that place and t equinoctial; or, by an arc of the meridian, ſhewing the height of t pole above the horizon.

For under the pole, or in the latitude of 90 degrees, the pole is the zenith, or is 90 degrees above the horizon; ſo that, in this ca the horizon coincides with the equinoctial.

And as many degrees as the obſerver goes from the pole towards t equator, ſo many degrees does his horizon go below the equator on o ſide, and approach the pole on the other ſide.

Therefore the pole approaches the horizon juſt as much as the zeni approaches the equator; that is, the height of the pole above the horiz is equal to the diſtance of the zenith from the equinoctial, which is equ valent to the diſtance of the obſerver from the equator, or is equal to t latitude.

958. *To convert time into degrees, and degrees into time.*

Note 15° 00′ 00″ = 1^h 00^m 00^s
5 00 00 = 0 20 00
1 00 00 = 0 04 00
0 15 00 = 0 01 00
0 05 00 = 0 00 20
0 01 00 = 0 00 04
0 00 15 = 0 00 01

When time is given.

959. Rule. Multiply the given hours by 15 gives degrees, to whi add 1° for every 4 minutes; for every overplus minu reckon 15′ of a degree; and for every ſecond of tim take 15″ of a degree.

When degrees are given.

960. Rule. Divide the given degrees by 15 for hours; multiply t remainder by 4 for min., adding to the product 1 m for every 15′ of a degree; the overplus minutes of degree multiplied by 4 gives ſeconds of time.

Exa

EXAM. I. *Reduce* $4^{h}\ 37^{m}\ 23^{ſ}$ *to grees, &c.?*

$4^{h}\ 37^{m}\ 23^{ſ}$
15

60° 00′ 00″ for 4 hours.
9 15 00 for 37 min.
5 45 for 23 ſeconds.

69 20 45

EXAM. II. *Reduce* 43° 29′ *to time?*

15) 43° 29′ ($2^{h}\ 53^{m}\ 56^{ſ}$.
30

13
4

52 + 1 = 53 minutes.

And 14′ × 4 = 56 ſeconds.

I. *Of the Tables of Declination and Right aſcenſion.*

Theſe tables are here diſpoſed into three parts.

I. *Tables of the Sun's declination*, at art. 1052, for every day in the year, well for leap-year, as for the firſt, ſecond and third years after: They contained in four pages, each being a year; the months whereof are top and bottom, and the days in the right and left hand columns.

Theſe tables are fitted to the meridian of London for each day at on, but by a proper correction they may be adapted to any other merian and intermediate hour. For which ſee art. 964, 965.

I. *A Table of the Sun's right aſcenſion*, at art. 1053. This table, like former, is made for every day in the year; but only for one year, auſe the alteration in right aſcenſion is ſo ſmall in ſeveral years, that is not neceſſary to be conſidered in nautical operations.

II. *A Table of the Right aſcenſions and declinations of ſome of the prinal fixed ſtars* is at art. 1054. The left hand column ſhews the ſituans of the conſtellations that are marked in the 2d column, whether he zodiac, or a northern or ſouthern conſtellation. The 3d column ws what part of the conſtellations the ſtars are in, whoſe names are he 4th column. The 5th column ſhews the marks that are annexed tars in the figures of the conſtellations, for the ready comparing of celeial obſervations. The figures in the 6th column ſhew the relative gnitude or ſize of the ſtars. The other two columns are according their titles.

The uſe of the Tables of Declination and Right aſcenſion.

I. Of the Sun's declination.

To find it. Seek the year and month at the head of the table, and the in the right or left hand column, againſt which, in the proper comn, is the declination ſought.

XAM. *Required the declination for the 10th of May, in the year 1753, the meridian of London?*

n the table for the year 1753, in the column ſigned at top with May, againſt the 10th day, is 17° 44′ N., which is the declination ſought; will ſerve alſo for the ſame month and day in the years 1757, 1761.

63. When theſe tables of declination are uſed in places more than to the eaſtward or weſtward of London, they ſhould be fitted to the idian of that place: For the tables which give the declination every at noon, have a daily variation ariſing gradually from noon to noon,

and divided among the intermediate hours; and as every 15° of lon
tude anſwers to an hour, conſequently places to the eaſtward or we
ward of London will have their declinations at noon, or other times
the day, different from what they are at London.

A table of the corrections for declination is at art. 1055: Where
left hand column is the daily variation, and the following columns c
tain the correction to the longitudes at the head of thoſe columns.

964. *To find the correct declination for any meridian.*

Rule. If the decl. be increaſing; then in W. longit. add the correct
(1055) to the tabular declination; but in E. longit. ſubtract
If the decl. be decreaſing; then in W. longit. ſubtract the c
rection from the tabular declin.; but in E. longit. add it.
And in either caſe the correct declination will be obtained.

Note. The decl. is increaſing from 21ſt of March to 21ſt of Ju
and from 22d of September to the 21ſt of December: A
decreaſing from 21ſt of June to the 22d of September; a
from the 21ſt of December to the 21ſt of March.

Exam. I. *What is the ſun's declination at noon on the 1ſt of June,* 17
at a place 120° *to the eaſtward of the meridian of London?*

June 1ſt, 1753, the decl. at London is 22° 07′; the increaſe to next day is
In the tab. art. 1055, under 120° lon. ſtands 3, againſt 8′ of daily diff.

Here the decl. is increaſ. and E. long. ſo 22 04, the diff. is the decl. ſough

[ſoug

But had it been W. longitude, then 22 10, the ſum, would be the d

Exam. II. *On March* 15, 1753, *what was the ſun's declination at n*
in a place 105° *to the weſtward of the meridian of London?*

March 15, 1753, the decl. at London is 1° 57′ S. the decr. to next day is
In tab. art. 1055, under 105 lon. ſtands 7 againſt 24′ of daily diff

Here the decl. is decr. and W. long. ſo 1 50 S. the diff. is the decl. ſoug

But had it been E. longitude, then 2 04 S. the ſum would be the d

In like manner may the tables of declination be fitted for any t
of the day, by increaſing or decreaſing the declination by a proportio
part of the difference between the declinations of that day and the ne
thus.

965. *To find the declination at any hour under any meridian.*

Rule 1ſt. Correct the declination for the given longitude as above
2d. If the declin. be increaſing; in the forenoon ſubtr. the correcti
and in the afternoon add it.
But if the declin. be decreaſing; in the forenoon add the correctio
and in the afternoon ſubtract.

This rule is the ſame as at art. 964, reckoning the time A. M. or
fore noon, in degrees of E. longitude, and the time P. M. or afterno
in degrees of W. longitude.

Exam. I. *What is the ſun's declination at 4 o'clock in the morning on e 1ſt of June, 1753, at London?*

4 o'clock, is 8 h. A. M. which is $\frac{1}{3}$ of the day before noon; the daily diff. is . The decl. is incr. and in forenoon; therefore $\frac{1}{3}$ of 8′, or 3′ being ſub-cted from 22° 07′, the decl. at noon, gives 22° 04′, the decl. at 8 o'clock the morning.

Or, 8 h. A. M. is the ſame as 120° to the eaſtward of London; and ſo the *am.* becomes the ſame as the 1ſt to art. 964.

Exam. II. *In a place 70° to the weſtward of the meridian of London, at is the ſun's declination at 2 h. 20 m. P. M. on the 15th of March, 1753?*

2 h. 20 m. P. M. is 35° weſt; and 70° and 35° make 105° weſt: So the am. is the ſame as *Exam.* II. art. 964.

When a ſtar is to be obſerved, it is convenient to know at what time the night it may be expected on the meridian; or at any known ne of the night, to find what ſtars will then be on the meridian. For performing of this, there is at art. 1053 a table of the ſun's right aſ-nſion; and at art. 1054 is a table of ſome of the chief ſtars, with their ht aſcenſion and declination.

To find the culminating of the ſtars.

966. Case I. *To find the time when any ſtar of the table will be upon the meridian.*

Rule. Subtract the ſun's right aſcenſion from the right aſcenſion of ſtar (increaſed if neceſſary by 24 hours); the remainder is the hours r mid-day, when the ſtar comes to the meridian. Thoſe hours, if leſs n 12, is the time after noon; or their overplus above 12, is the time r midnight.

Exam. I. *Required the time when ſtar Arcturus comes to the meridi-on the 1ſt of September, 1753?*

cturus's right aſcen. = $14^h\ 03^m$

he ſun's right aſcen. = 10 42

he remain. is ✱ culm. = 3 21

hat is, the ſtar Arcturus will be on meridian of London at 21 minutes r 3 in the afternoon.

Exam. II. *On the 25th of February, 1753, at what hour will the ſtar Virgin's ſpike be on the meridian?*

Virgin's ſpike right aſcen. = $13^h\ 12^m$

Which added to 24^h gives 37 12

The ſun's right aſcen. = 22 34

The remain. is ✱ culm. = 14 38

Or, the culm. abating 12 is 2 38

That is, the ſtar will be on the meridian at 38 min. after 2 in the morning.

967. Case II. *To find if any ſtar in the table will be on or near the meridian at a propoſed time.*

Rule. Add the given time, reckoned from noon, to the ſun's right nſion; ſeek the ſum (rejecting 24 h. if the ſum is greater) among the t aſcenſions of the ſtars, which if found there, the ſtar anſwering it be on the meridian at the time propoſed: Or, the ſtar, whoſe right nſion is neareſt that ſum, will be on the meridian the neareſt to the n time.

Exam. *January 25th, 1754: What ſtar will be on the meridian about o'clock at night?*

n. 25, at noon, the ſun's right aſcenſion is 20 h. 32 m.; and at 10 hours it may be reckoned 20 h. 34 m.; to which the given time being added, es 30 h. 34 m.; and abating 24 h. is 6 h. 34 m. which is the right aſcenſion e ſtar Syrius; So Syrius will be on the meridian at 10.

SECTION IV.

Of the Projection of the ſphere.

968. PROBLEM I.

To project the ſphere upon the plane of the ſolſtitial colure, or upon plane of the meridian of any place; thoſe planes being ſuppoſed to coincide.

For this projection, the eye is ſuppoſed to be in the firſt point of ♈, the common interſection of the equator, ecliptic, and equinoctial colu that being the pole of the plane of projection, or primitive circ Plate IX. Fig. 4.

1ſt. With the chord of 60 degrees deſcribe a circle PESQ to repreſ the ſolſtitial colure, whoſe centre ♈ is its pole. (44

2d. A diameter EQ will be the equator, and another PS at right ang to it will ſhew the equinoctial colure (440), or the axis of the wor whoſe extremities P, S, will be the north and ſouth poles.

3d. *For the parallels of declination.* On the primitive circle, beginni at E and Q, lay off the chords of the given degrees of declination, ſ poſe every 10 degrees, and alſo the diſtances of the *tropics* and *po circles* from the equator, namely, 23½° and 66½°: Then from the cen ♈ in the axis PS produced, apply the reſpective ſecants of the comp ments of the degrees laid on the primitive, and theſe will give the ce tres of the correſponding parallels of declination; from which centr with the extents to the ſeveral diviſions in the circumference, deſcri the ſmall circles (456) 10, 10; 20, 20; &c.; and theſe will be the p rallels of declination required: Among which *a* ♋, *b* ♑, are the trop of Cancer and Capricorn; and *c c*, *d d*, the artic and antartic polar circl

4th. *For the circles of right aſcenſion, or hour circles.* In the diame EQ produced, lay off from the centre ♈, both ways, the tangents 15°, 30°, 45°, 60°, 75°, reſpectively, and they will give the centres circles to be deſcribed thro' P and S, and cutting the equator in the poi repreſenting the 24 hours; the ſolſtitial colure being the 12 o'clock, a the equinoctial colure, PS, the 6 o'clock hour circles. And in l manner may any other of theſe kind of circles be drawn. (45

5th. *The ecliptic* ♋ ♑ is drawn, making with the equator an an of 23½°; whoſe poles *c*, *d*, are the interſections of the polar circles w the ſolſtitial colure.

6th. *Parallels of celeſtial latitude* are drawn parallel to the ecliptic, in ſame manner as the circles of declination are drawn parallel to the equat

7th. *Circles of celeſtial longitude* are deſcribed thro' *c*, *d*, the poles the ecliptic, in the ſame manner as the circles of right aſcenſion were ſcribed thro' P, S, the poles of the equator; and thus were the diviſi of the ecliptic found that are marked with the ſigns.

8th. *The horizon* is repreſented by drawing a diameter HR making angle with the axis PS, equal to the latitude of the place; and the pc of the horizon Z, N, the zenith and nadir, are at 90° diſt. from the cir

9th. *Azimuth, or vertical circles,* making any angle with the meridi are deſcribed like circles of right aſcenſion: Thus ZN is the prime ve cal, and ZAN is another azimuth, 45° from the ſouth.

10th. *Almicanthers, or parallels of altitude,* are in this projection dra parallel to the horizon, in like manner as were the circles of declinat drawn parallel to the equator. 9

59. PROBLEM II.

To project the ſphere upon the plane of the horizon.

In this projection the eye is ſuppoſed in one of the poles of the ho-zon, or plane of projection. Plate IX. Fig. 5.

1ſt. *The horizon* is repreſented by the primitive circle, where the upper II is the ſouth, the lower XII the north, E the eaſt, and Q the weſt points.

2d. *The azimuth circles* are repreſented by diameters drawn thro' z, the ntre or pole of the horizon: Thus the diameter XII, XII is for the meri-ian, and EZQ for the prime vertical; and other azimuth circles, form-g any angle with the meridian, are readily drawn by laying off their ſtances in the primitive from the north or ſouth points.

3d. *Parallels of altitude* are concentric to the primitive, and are de-ribed about the pole z with the half tangent of their diſtance from it: hus the ſmall circle, whoſe diameter is *a b*, is a parallel of altitude 10° ove the horizon, or at 80° diſtant from its pole z.

4th. *The equinoctial's* diſtance from the zenith, is equal to the latitude the place, and therefore this circle makes with the horizon an angle, ich is meaſured by the complement of the latitude; then ſetting off m the centre z, in z XII continued, the tangent of 50° (the latitude this example being 40°), it will give the centre of the circle EAQ, preſenting the equinoctial; and the half tangent of 50°, ſet the ſame y from z, will give P, the pole of the world.

5th. *The ſix o'clock hour circle* paſſes thro' the poles of the world, mak-g with the horizon an angle equal to the meaſure of the latitude; erefore taking in the meridian from z towards A, the tangent of the itude 40°, it gives G, the centre of the 6 o'clock hour circle EPQ.

6th. *The hour circles* paſs thro' the poles of the world, and make with e another angles of 15 degrees: Therefore (435) in a line DE, drawn ro' G at right angles to the meridian, ſet off on both ſides of G the tan-nts 15°, 30°, 45°, 60°, 75°, to the radius PG, and they will give the ntres of the ſeveral hour circles paſſing thro' P, cutting the horizon and uinoctial in the hour points.

7th. *The polar circles, tropics, and other circles of declination*, are de-ibed parallel to the equinoctial, about its pole P, at given diſtances m it, either by finding the centres of ſuch parallels as ſhewn in art. 454; by ſetting off on each ſide of z the half tangents of their greateſt d leaſt diſtances from z; then the middles of thoſe intervals are the ntres ſought. Thus; the artic circle is diſt. from P 23½°; then to, d from, ZP = 50°, add and take 23½°, gives 73½° and 26½°; the half gents of theſe ſet off from z, gives *p* and *q*; then a circle being de-ibed on the diameter *p q* is the artic circle.

In like manner will the centres of the tropic of Cancer *c* ♋ *c*, and of pricorn *d* ♑ *d*, be obtained.

8th. *The northern portion of the ecliptic* ♈ ♋ ♎ is deſcribed from a centre tant from z towards P, the tang. of 73½°, =∠ the ecliptic makes with the rizon.

9th. *Circles of longitude* ♈ *p* ♎, *p* ♉, *p* ♊, *p* ♌, *p* ♍, are deſcribed thro' the pole of the ecliptic, from centres in the line BFC; in like manner the hour circles were deſcribed thro' P, the pole of the equator.

10th. *Circles of celeſtial latitude*, VIII *q* VI, are deſcribed about *p*, as th circles of declination were deſcribed about P, the pole of the equinoctia

970. PROBLEM III.

To project the ſphere upon the plane of the equator.

In this projection the eye is ſuppoſed to be in one of the poles of th equator, ſuppoſe in the ſouth pole, and projecting the north hemiſpher Plate IX. Fig. 6.

1ſt. *The equator* is repreſented by the primitive circle, whoſe cent and pole is P.

2d. *The hour circles* are expreſſed by diameters making angles of 15 with one another; of which XII P XII is the meridian, or ſolſtitial colure, and VI P VI the 6 o'clock circle, or equinoctial colure.

3d. *Circles of declination* are circles parallel and concentric to the equator, deſcribed from its centre with radii equal to the half tangents o their ſeveral diſtances from the pole P, or half co-tangents of their degrees of declination: Thus *pq* the artic circle, and *a* ♋ the tropic o Cancer, are deſcribed with the half tangents of 23½° and 66½° reſpectively; and ſo of the others.

4th. *The ecliptic* making an angle of 23½° with the equator; therefor the tangent of theſe degrees laid from P towards *a* will give the centre fo deſcribing the ecliptic ♈♋♎, whoſe pole *p* is in the polar circle.

5th. *Circles of longitude* are deſcribed thro' *p*, the pole of the ecliptic in like manner as the hour circles were deſcribed thro' P, the pole of th equator in the laſt problem; and thus were the diviſions ♉, ♊, ♌, ♍ obtained.

6th. *Circles of celeſtial latitude* are projected in the ſame manner a the circles of declination in the laſt problem.

7th. *The horizon of any place*, ſuppoſe of London, being inclined t the equator in an angle equal to the co-latitude, 38° 28′; the tangen of this laid from P towards ♋, and the half tangent laid from P to z will give the centre, and z the pole, of the horizon HOR.

8th. *The prime vertical* HZR making an angle with the equator equ to 51° 32′, the latitude of the place, its centre is found by laying th tangent of 51° 32′ from P towards O.

9th. *Azimuth circles*, making given angles with the meridian ZO, ar thus deſcribed: In a line drawn thro' the centre of the prime vertical, a right angles to the meridian, take diſtances from that centre, equal to th tangents of the propoſed azimuth angles, the ſemidiameter of the prim vertical being the radius, thoſe diſtances give the centres ſought; an thus was the azimuth circle ZA deſcribed.

10th. *Parallels of altitude* are deſcribed about Z, the pole of the horizon, at the diſtances of the co-altitudes, in the ſame manner as wer the circles of declination, in the laſt problem, deſcribed about P, the po of the equator; and thus was the ſmall circle V *b* VII deſcribed at 10° diſtant from the horizon, or 80° diſtant from its pole Z.

1.

PROBLEM IV.

To project the ſphere upon the plane of the ecliptic.

The eye is here ſuppoſed to be in one of the poles of the ecliptic, and ence ſeeing the northern hemiſphere projected. Plate IX. Fig. 7.

1ſt. *The ecliptic* is here repreſented by the primitive circle, whoſe cen- e *p* is the pole of the ecliptic.

2d. *Circles of longitude* are herein ſhewn by diameters; thoſe making gles of 30° with one another, being drawn thro' the diviſions marked ith the ſigns of the zodiac.

3d. *Parallels of celeſtial latitude*, are circles deſcribed about *p* concen- c to the ecliptic; ſuch is the ſmall circle whoſe diameter is *a b*, re- eſenting the parallel of 10° of latitude.

4th. *The equator* making an angle with the ecliptic of $23\frac{1}{2}^{\circ}$; there- re the tangent of this inclination laid from *p* towards ♋, will give the ntre of the equator ♈ XII ♎; and the half tangent of $23\frac{1}{2}^{\circ}$ laid from the ſame way, gives P for the pole of the equator.

5th. *The equinoctial colure*, which here makes *the ſix o'clock circle*, makes angle with the ecliptic of $66\frac{1}{2}^{\circ}$; therefore the tangent of $66\frac{1}{2}^{\circ}$ laid m *p* towards ♑, gives the centre of the 6 o'clock circle ♈ P ♎.

6th. *Hour circles* paſſing thro' P, and making angles of 15° with one other, are deſcribed from centres, found in a right line paſſing thro' the ntre of ♈ P ♎, and drawn at right angles to the ſolſtitial colure ♋ *p* ♑; laying off in that line the tangents of 15°, 30°, 45°, 60°, 75°, reck- ed from the centre of ♈ P ♎, on both ſides, the ſemidiameter of this rcle being the radius. Theſe hour circles cut the equator in the hour ints.

7th. *Parallels of declination*, ſuch as the tropic of Cancer, and artic rcle, whoſe diameters are 12, 12, and *p q*, are deſcribed by laying off m *p* the half tangents of their greateſt and leaſt diſtances: Thus *q* be- g diſtant from *p* 47°, make $pq = \frac{1}{2}$ tang. of 47°, the middle of *p q* will the centre of the polar circle.

8th. *The horizon* HOR is to make an angle with the ecliptic equal to e diff. between the co-lat. and the obliquity of the ecliptic, when P is ojected to the north of *p*; otherwiſe, that angle is equal to the ſum of oſe quantities. And for London, where the ſaid diff. = (38° 28′ — 3° 29′ =) 14° 59′, the tangent of 14° 59′ gives the centre of HOR, d the half tang. gives Z the zenith.

9th. *The prime vertical* HZR is deſcribed, by laying from *p* towards O e cotangent of *p* Z for a centre.

10th. *Azimuth circles* are deſcribed thro' Z, making given angles with e meridian ZO, by finding their centres in a line drawn thro' the ntre of HZR, in the manner deſcribed for the hour circles, art. 969.

11th. *Parallels of altitude* are repreſented, by deſcribing ſmall circles rallel to the horizon HOR, at given diſtances from it; or, which mes to the ſame, deſcribing ſmall circles about the pole Z, at diſtances ual to the complements of the given altitudes: And thus the circle *c* was deſcribed for a parallel of 33° of altitude.

SECTION V.

Problems of the ſphere.

972. PROBLEM V.

Given the ſun's longitude, and the obliquity of the ecliptic; Required the ſun's right aſcenſion and declination.

Exam. *Let the obliquity of the ecliptic, or the ſun's greateſt declinatio be 23° 29′, and the ſun's place be 13° 16′ in Taurus: Required the reſt?*

CONSTRUCTION.

In the primitive circle PESQ repreſenting the plane of the ſolſtitial colure, whoſe centre is ♈, draw a diameter EQ for the equator, and a right angles to EQ draw a diameter PS for the equinoctial colure: Mak E ♋ = 23° 29′, and draw a diameter ♋♑ for the ecliptic, in which (447) take ♈☉ = 43° 16′ for the ſun's diſtance from the point ♈ Thro' P☉S deſcribe (163) a circle of right aſcenſion.

COMPUTATION. See art. 513, 514.

In the right angled ſpheric triangle ♈☉B.

Given ſun's longitude	♈☉	= 43° 16′	Req. right aſcen. ♈B
greateſt declinat.	∠☉♈B	= 23 29	preſ. declin. B☉

To find the preſent declination.

As Radius	=	R	10,00000
To ſ. ſun's lon.	=	43° 16′	9,83594
So ſ. great. decl.	=	23 29	9,60041
To ſ. preſ. decl.	=	15 51	9,43635

To find the right aſcenſion.

As Radius	=	R	10,0000
To t. ſun's lon.	=	43° 16′	9,9737
So coſ. obl. ecl.	=	23 29	9,9624
To t. rt. aſcen.	=	40 48	9,9361

973. While the ſun is moving from ♈ to ♋, or is in the firſt quadran of the ecliptic, the given longitude is the hypothenuſe in the triangl ♈☉B, the declination B☉ is north, and ♈B is the right aſcenſion.

974. When the ſun has paſt the ſolſtice ♋, and is deſcending towards ♎, he is then ſaid to be in the ſecond quadrant, and his longitude o diſtance from ♈ being taken from 180°, the remainder ♎☉ becomes the hypothenuſe, and the declination is ſtill north; but the arc B♎ found fo the right aſcenſion, is only the ſupplement, and muſt therefore be taken from 180°.

975. The ſun having paſt the point ♎, and deſcending towards ♑, is got into the third quadrant; the longitude then, reckoned from ♈, will be greater than 180°: In this caſe the exceſs above 180°, or the diſtance the ſun is removed from ♎, will be the hypothenuſe ♎☉; the declination will be ſouth; and the arc ♎A, found for the right aſcenſion, muſt be added to 180°, to give the right aſcenſion eſtimated from ♈.

976. When the ſun has paſt the ſolſtice ♑, and is aſcending towards ♈, he is then in the fourth quadrant; therefore the longitude is greate than 270°, and muſt be taken from 360°, to give the hypothenuſe ♎☉. Herein the declination is ſouth, and the right aſcenſion ♎A, found by the proportion, muſt be taken from 360°, to give the right aſcenſion from ♈.

977. At equal diſtances from the equinoctial points ♈ or ♎, the ſun will have equal quantities of declination; but will be of different names, according as it is on the north or ſouth ſides of the equinoctial.

ASTRONOMY Pl: IX.

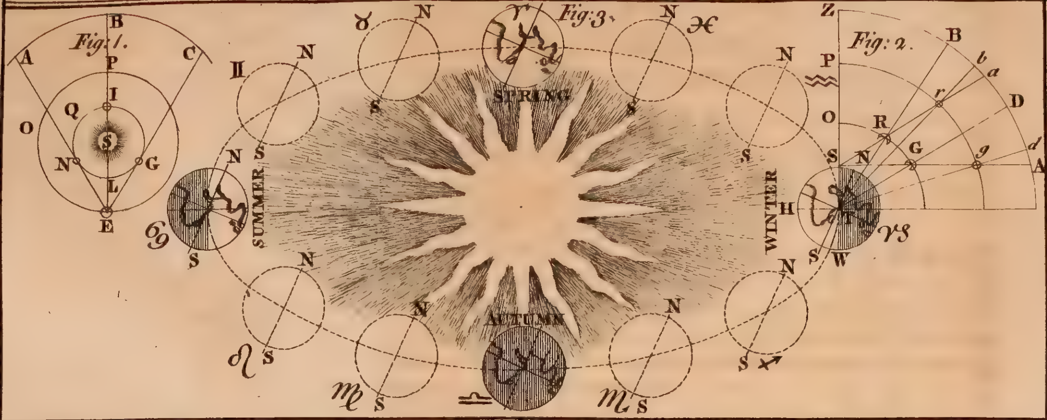


Fig: 1.

Fig: 2.

Fig: 3.

Projection on the Solstitial Colure or Meridian

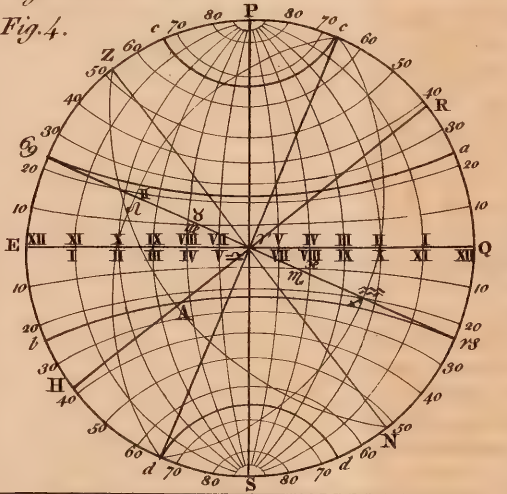


Fig. 4.

Projection on the plane of the Horizon.

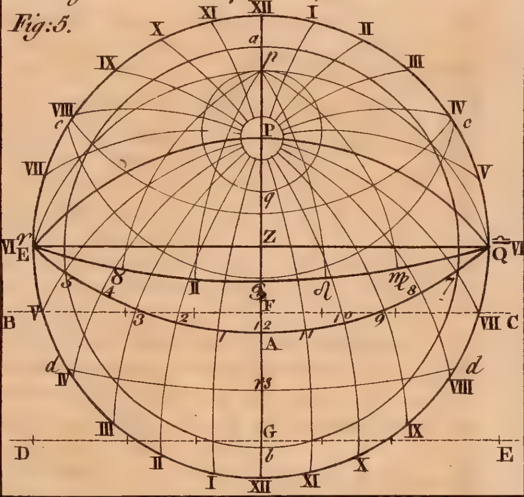


Fig: 5.

Projection on the plane of the Equator.

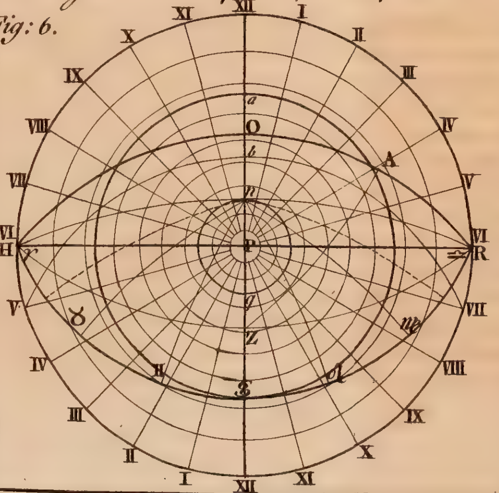


Fig: 6.

Projection on the plane of the Ecliptic.

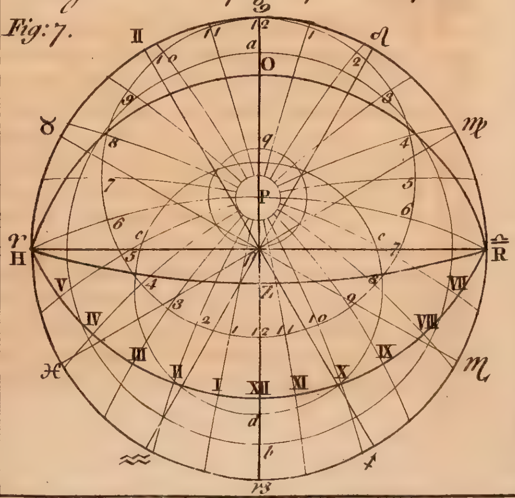


Fig: 7.

T. Jefferys sculp.

8, PROBLEM V.

Given the obliquity of the ecliptic, and the ſun's preſent declination; Required the ſun's longitude and right aſcenſion.

EXAM. *The obliquity of the ecliptic being 23° 29′, what is the ſun's lon- ude and right aſcenſion when he has 22° 43′ of north declination?*

CONSTRUCTION.

Having deſcribed the ſolſtitial colure, drawn the equator E Q, the axis , and the ecliptic ♋ ♑, as before; make E *n*, Q *n*, equal to the given clination, and (3d 968) deſcribe the parallel of declination *n n*, its inter- ction with the ecliptic gives ☉ the ſun's place; thro' P, ☉, S, deſcribe e circle of right aſcenſion P ☉ S.

COMPUTATION. See art. 516, 517.

In the right angled ſpheric triangle ♈ ☉ B.

Given ſun's greateſt decl. ∠ ☉ ♈ B = 23° 29′ } Required ſun's longit. ♈ ☉.
preſent decl. ☉ B = 20 43 } rt. aſcen. ♈ B.

To find the ſun's longitude.			*To find the ſun's right aſcenſion.*		
ſ. ☉ great decl.	= 23° 29′	0,39959	As Radius	= R	10,00000
ſin. preſ. decl.	= 20 43	9,54869	To cot. gr. decl.	= 23° 29′	10,36204
Radius	= R	10,00600	So tan. preſ. decl.	= 20 43	9,57772
ſin. ☉ longit.	= 62 35	9,94828	To ſin. rt. aſcen.	= 60 31	9,93976

Therefore the ſun is in ♊ 2° 35′, or in ♋ 27° 25′, according as the ne of the year is before or after the ſummer ſolſtice.

9. PROBLEM VII.

Given the obliquity of the ecliptic, and the ſun's right aſcenſion; Required the ſun's longitude and preſent declination.

EXAM. *When the ſun's right aſcenſion is 60° 31′, what is his longitude d preſent declination, the greateſt declination being 23° 29′?*

CONSTRUCTION.

The ſolſtitial colure, equator, axis and ecliptic being deſcribed, as be- re, make ♈ B = given right aſcenſion (4th 968), and deſcribe the rcle PBS, cutting the ecliptic in ☉ the ſun's place.

COMPUTATION.

In the right angled ſpheric triangle ♈ ☉ B; the leg ♈ B and ∠ ☉ ♈ B be- g known, the hypoth. ♈ ☉, and other leg ☉ B, are found as in art. 20, 521.

s Rad : cot. gr. decl. : : cot. rt. aſcen. [: cot. ☉ long.	As Rad : tan. gr. decl. : : ſin. rt. aſcen. [: tan. pr. decl.
s Rad : cot. 23° 29′ : : cot. 60° 31′ [: cot. 62° 35′.	As Rad : cot. 23° 29′ : : ſin. 60° 31′ [: tan. 20° 43′.

Three other problems may be formed out of the four things con- rned, or greateſt declination, preſent declination, longitude and right cenſion: But theſe being of little more importance than as an exerciſe r right angled ſpheric triangles, they are therefore omitted.

980. PROBLEM VIII.

Given the latitude of the place, and the ſun's preſent declination; Required the ſun's altitude and azimuth at 6 o'clock.

EXAM. *At London, in lat.* 51° 32′ *N., on the longeſt day, when the ſ declination is* 23° 29′ *: Required the ſun's altitude and azimuth at* 6 *o' in the morning or evening?*

CONSTRUCTION.

Deſcribe the meridian; draw the horizon HR, and prime vertical z make RP = latitude 51° 32′ N.; draw the 6 o'clock hour circle PS, equator EQ, the 23° 29′ N. parallel of declination *nm*, cutting th o'clock hour circle PS in ⊙; and thro' z, ⊙, N, deſcribe the azim circle z⊙N, cutting the horizon in A; then the things given and quired fall in either of the triangles z⊙P or ♈⊙A, they being ſupp mental triangles one to the other.

COMPUTATION.

In the ſpheric triangle z⊙P, right angled at P. (5

Given the co-latit. ZP = 38° 28′ } Required the co-altitude z⊙
the co-decl. ⊙P = 66 31 } the azimuth ∠⊙ZP

Or in the ſpheric triangle ♈A⊙, right angled at A. (513, 5

Given the latit. A♈⊙ = 51° 32′ } Required the altitude A⊙.
the decl. ♈⊙ = 23 29 } the co-azimuth ♈A.

To find the altitude A⊙.

As Radius	=	R	10,00000
To ſin. decl.	=	23° 29′	9,60041
So ſin. lat.	=	51 32	9,89375
To ſin. alt.	=	18 11	9,49416

To find the azimuth AR.

As Radius	=	R	10,00
To coſ. lat.	=	51° 32′	9,79
So tan. decl.	=	23 29	9,63
To cot. azim.	=	74 53	9,43

For the arc AR meaſures the ∠RZA, the azimuth. (3

981. On the ſhorteſt day at London, the parallel of S. declination the 6 o'clock hour circle below the horizon; and as the triangles ♈A ♈*a*⊙, are congruous, the depreſſion below the horizon, on the ſhort day, at 6 o'clock, will be equal to the altitude at the ſame hour on longeſt day; and the azimuth will be alſo equal, if eſtimated from ſouth.

So that on the 21ſt of June, at London, the ſun will bear N. 74° 53′ at 6 o'clock in the morning, and N. 74° 53′ W. at 6 in the evenin But on the 21ſt of December, at the ſame hours, it will bear S. 7 53′ E., and S. 74° 53′ W.

982. From a due conſideration of this problem it is evident, that as t declination increaſes, the altitude increaſes and the azimuth leſſens; a the contrary happens while the declination is diminiſhing: So that on t days of the equinoxes, or when the ſun has no declination, the altitu at 6 o'clock will be nothing, or the ſun will be in the horizon; and t azimuth being then 90 degrees, the ſun will be due eaſt in the mornin and weſt in the evening; that is, on the days of the equinoxes the ſ riſes and ſets at ſix, in the eaſt and weſt points of the horizon.

83. PROBLEM IX.

Given the latitude of the place, and the ſun's declination; Required the altitude and hour when the ſun is due eaſt or weſt.

EXAM. *At London, in lat.* 51° 32′ *N., what is the ſun's altitude, and he hour when he is due eaſt or weſt, on the longeſt day, or when the decliation is* 23° 29′ *N.?*

CONSTRUCTION.

Deſcribe the primitive circle to repreſent the meridian of London, raw the horizon HR, and the prime vertical ZN; make RP = 51° 32′, he given latitude, draw the 6 o'clock hour circle PS, the equator EQ, he parallel of declination *n m* (3d 968), cutting the prime vertical in ⊙, nd thro' P⊙S deſcribe (163) the hour circle POS, cutting the equator n A.

Here the things concerned in the problem fall in either of the triangles Z⊙ or ♈A⊙.

COMPUTATION.

In the ſpheric triangle PZ⊙, right angled at Z.

Given the co-latit. PZ = 38° 28′ } Required the co-alt. Z⊙.
the co-decl. P⊙ = 66 31 } the hour fr. noon ∠ZP⊙.

Or in the ſpherical triangle ♈A⊙, right angled at A.

Given the latit. ∠A♈⊙ = 51° 32′ } Required the altitude ♈⊙.
the decl. A⊙ = 23 29 } the hour after 6 ♈A.

To find the altitude ♈⊙. (516)

ſ. lat. ∠A♈⊙	=	51° 32′	0,10625
o ſin. decl. A⊙	=	23 29	9,60041
Radius	=	R	10,00000
o ſin. alt. ♈⊙	=	30 36	9,70666

To find the hour after 6.

As Radius	=	R	10,00000
To cot. lat. A♈⊙	=	51° 32′	9,90009
So tan. decl. A⊙	=	23 29	9,63796
To ſ. h. fr. 6 A♈	=	20 12	9,53805

Which 20° 12′ converted into time (960), gives 1 h. 20 m. 48 ſ. for e time after 6 in the morning, and before 6 in the evening, when the n will appear due eaſt and weſt; which will be at 7 h. 20 m. 48 ſ. in e morning, and 4 h. 39 m. 12 ſ. in the afternoon.

Or, The compl. of 20° 12′, *viz.* 69° 48′ put into time, which gives h. 39 m. 12 ſ., ſhews the time before and after noon when the ſun will due eaſt or weſt.

984. This problem worked for the ſhorteſt day, namely in the △♈*a*⊙, hich is congruous to ♈A⊙, would give the ſun's depreſſion at the me when he was eaſt or weſt, which would be before 6 in the morng and after 6 in the evening, by as much as was found above, *viz.* h. 20 m. 48 ſ.

985. By this problem it appears, that when the latitude of the place d the ſun's declination have the ſame name, then, the greater the denation and latitude, the greater the altitude and time from 6: And ving contrary names, the ſame things happen; but with this difference, at in the former caſe the days lengthen on account of the increaſe of the itude and declination; whereas, in the latter caſe, the days ſhorten on at account.

986. PROBLEM X.

Given the latitude of a place, and the ſun's declination; Required his amplitude and aſcenſional difference.

EXAM. *At London, whoſe lat. is 51° 32′ N., in the year 1753, on t 21ſt of June, being the longeſt day, when the ſun's declination is 23° 29′ N. How far from the north does the ſun riſe and ſet, at what time, and wh is the length of the day and night?*

CONSTRUCTION.

Let the primitive circle repreſent the meridian of the place, and th diameter HR the horizon; from R, the north point thereof, take RP = 51° 32′ for the latitude, draw the axis or 6 o'clock hour circle PS, ar at right angles to it, draw the equator EQ; make E*n*, Q*m* = 23° 2 the declination, and (3d 968) deſcribe the parallel of declination *n m*, cu ting the horizon in ☉ the place of the ſun at its riſing and ſetting thro' which deſcribe (163) the hour circle P☉S.

COMPUTATION.

Now as the arc QR = co-latitude, meaſures the ∠Q♈R.

In the ſpheric triangle ♈☉A, right angled at A.

Given ſun's decl. A☉ = 23° 29′ } Required the amplitude ♈☉.
co-latit. ∠A♈☉ = 38 28 } the aſcen. diff. ♈A.

To find the amplitude ♈☉.

As ſ. co-l. ∠A♈☉	= 51° 32′	0,20617
To ſin. decl. A☉	= 23 29	9,60041
So Radius	= R	10,00000
To ſin. amp. ♈☉	= 39 50	9,80658

This 39° 50′ is the amplitude reckoned from the eaſt or weſt points the horizon: But its complemer 50° 10′ ſhews how far from th north the ſun riſes or ſets on th longeſt day at London.

To find the aſcenſional difference ♈A.

As Radius	= R	10,00000
To t. lat. ∠A♈☉	= 51° 31′	10,09991
So tan. decl. A☉	= 23 29	9,63796
To ſ. aſ. diff. ♈A	= 33 09	9,73787

Which 33° 09′ converted into tim (960) gives 2 h. 12 m. 36 ſ. for th time which the ſun riſes before, an ſets after, the hour of ſix on th longeſt day.

987. Suppoſe *r s* to be a parallel of declination as far ſouth, as *m* is north; then the hour circle PBS, paſſing thro' ☉ the place of the ſu at its riſing or ſetting, will form a triangle ♈☉B = △♈☉A, where th amplitude is to the ſouthward of the eaſt and weſt points.

988. Hence it is evident, *that when the latitude and declination hav the ſame name, the ſun riſes before, and ſets after 6: But when of contrar names, the ſun riſes after, and ſets before 6.*

989. And as the ſun deſcribes the parallel of declination *n m* in 24 hours, being at *n* when it is noon, and at *m* when it is midnight; therefore the time in paſſing from *m* to ⊙, or the time of riſing, being doubled, gives the length of the night; and the time of ſetting being doubled, muſt give the length of the day.

Then to, and from	6^h	0^m	0^s
Add and ſubtract the aſcen. differ.	2	12	36
Sum, gives ⊙ ſetting	8	12	36
Diff. gives ⊙ riſing	3	47	24
Length of day is	16	25	12
Length of night is	7	34	48

990. But when it is the ſhorteſt day at London, which is, when the ſun has 23° 29′ ſouth declination; then the lengths of the day and night change places; the day being 7 h. 34 m. 48 ſ. long, and the night 16 h. 25 m. 12 ſ.

991. When the latitude and declination have the ſame name, the difference between the right aſcenſion and the aſcenſional difference, is the oblique aſcenſion; and their ſum is the oblique deſcenſion.

But when they are of contrary names, their ſum is the oblique aſcenſion, and their difference is the oblique deſcenſion.

992. When the declination is equal to the co-latitude of any place (which can only happen to places within the polar circles), then the parallel of declination will not cut the horizon, and conſequently the ſun will not ſet in thoſe places during the time his declination exceeds the co-latitude: And the ſame may be ſaid of the ſtars, every one of which, whoſe co-declination, or polar diſtance, is not leſs than the latitude; or, which is the ſame thing, whoſe declination is not leſs than the co-latitude of a place, thoſe ſtars will never deſcend below the horizon of that place. But this is to be only underſtood, when the ſun or ſtars are in the ſame hemiſphere with the given place; for when the ſun or ſtars are in a contrary hemiſphere with any place, whoſe co-latitude does not exceed the declination of thoſe celeſtial objects, then will they never riſe above the horizon of that place, and conſequently are never viſible there.

993. PROBLEM XI.

Given the latitude of a place, the ſun's declination and altitude; Required the hour from noon, and the ſun's azimuth.

EXAM. *In the latitude of* 51° 32′ *N. the ſun's altitude was obſerved to be* 46° 20′, *when his declination was* 23° 29′ *N.: What was the ſun's azimuth, and the hour when the obſervation was made?*

CONSTRUCTION.

Let the primitive circle ZRNH repreſent the meridian of London, HR the horizon, ZN the prime vertical; make RP = 51° 32′ the height of the pole at London (957), draw the axis PS, and the equator EQ. Lay off the declination E *n*, Q *m*, 23° 29′ N.; the altitude H *r*, R *s*, 46° 20′; and (456) deſcribe the parallel of declination *n m*, and the parallel of altitude *r s*, cutting one another in ⊙ the place of the ſun at that time. Thro' Z, ⊙, N, deſcribe an azimuth circle Z⊙N, and thro' P, ⊙, S, deſcribe an hour circle P⊙S: Then the angles ⊙ZP, ⊙PZ, being meaſured (448), will give the azimuth and hour from noon required.

COMPUTATION.

In the oblique angled ſpheric triangle P⊙Z.

Given the co-lat. ZP = 38° 28′
the co-alt. or zen. diſt. Z⊙ = 43 40
the co-dec. or pol. diſt. ⊙P = 66 31

Required the azim. ∠⊙ZP. and the h. fr. noon ∠⊙PZ. See art. 550.

To find the azimuth ∠⊙ZP.

Here Z⊙ = 43° 40′
ZP = 38 28
P⊙ = 66 31
Z⊙ − ZP = 5 12 = D.
71 43 | 35° 51½′
2)
61 19 | 30 39½

Then Co-ar. ſin. co-lat. = 38° 28′ 0,20617
Co-ar. ſin. co-alt. = 43 40 0,16086
Sin ½ ſum co decl. & D = 35 51½ 9,76774
Sin. ½ diff. co-decl. & D = 30 39½ 9,70750
The ſum of the four logs. 19,84227
The ½ ſum gives 56° 30′ 9,92113

Which doubled, gives 113° 30′ for the azimuth ſought, reckoning from the north.

To find the hour from noon, ∠⊙PZ.

Here P⊙ = 66° 31′
PZ = 38 28
⊙Z = 43 40
P⊙ − PZ = 28 03 = D.
71 43 | 35° 51½′
2)
15 37 | 7 48½

Then Co-ar. ſin. co-decl. = 66° 31′ 0,03755
Co-ar. ſin. co-lat. = 38 28 0,20617
Sin. ½ ſum co-decl. & D = 35 51½ 9,76774
Sin. ½ diff. co-decl. & D = 7 48½ 9,13309
The ſum of the four logs. 19,14455
The ½ ſum gives 21° 56′ 9,57227

This doubled, gives 43° 52′ for the meaſure of the hour from noon, which is 2 h. 55 m. 28 ſ.

Hence it appears, that the obſervation was made either at 9 h. 4 m. 32 ſ. in the morning, or at 2 h. 55 m. 28 ſ. in the afternoon.

The azimuth being firſt found, the hour from noon might have been found by the proportion between oppoſite ſides and angles.

Had the declination and latitude been of contrary names, the ſame d of operation would have been uſed to find the things required; only ſide ⊙ P would have been obtuſe, by adding the declinat. to 90°, inſtead ſubtracting it as in the caſe of the lat. and decl. having like names.

PROBLEM XII.

Given the latitude of the place, and the ſun's declination;
Required the time when the twilight begins and ends.

EXAM. *At what time does the twilight begin and end at London on the of May*, 1753, *the latitude being* 51° 32′ *N., and the declination at time being* 15° 12′ *N.*

CONSTRUCTION.

Let the circle ZRNH repreſent the meridian of the place, HR the horizon, ZN the prime vertical, and *t s* a ſmall circle parallel to the horizon deſcribed at 18 degrees below it (456); lay off the latitude RP, w the axis PS, the equator EQ, and deſcribe the parallel of declination (3d 968), and where *n m* cuts *t s* in ⊙, is the ſun's place at the time the beginning or end of the twilight; thro' ⊙ deſcribe (163) the vertical circle Z⊙N, and the hour circle P⊙S; then the ∠ZP⊙ being meaſured (448), will give the time before or after noon as required.

COMPUTATION.

In the oblique angled ſpheric triangle Z⊙P.

Given the co-lat. ZP = 38° 28′
the polar diſt. P⊙ = 74 48
the zenith diſt. Z⊙ = 108 00

Req. the hour fr. noon ∠ = ZP⊙
The manner of ſolution is the ſame as ſhewn in art. 550.

e P⊙ = 74° 48′
PZ = 38 28

⊙Z = 108 00
− PZ = 36 20 = D.

144 20 | 72° 10′
2) 71 40 | 35 50

Then Co-ar. ſin. polar diſt.	= 74°	48′	0,01547
Co-ar. ſin. co-latit.	= 38	28	0,20617
Sine ½ ſum of zen.d.&D	= 72	10	9,97861
Sine ½ diff. of zen.d.& D	= 35	50	9,76747
The ſum of theſe four logs:			19,96772
The half ſum gives 74° 28′			9,98386

Which doubled gives 148° 56′ for ∠ZP⊙.

And 148° 56′ reduced to time, gives 9 h. 56 m′ either before or after noon; that is, the twilight begins at 2 h. 04 m. in the morning, and ends at 9 h. 56 m. in the evening on the 1ſt of May at London.

995. When the declination becomes greater than the difference between the co-latitude and 18 degrees, then the parallel of declination *n m* will not cut the parallel *t s* 18 degrees below the horizon, and conſequently at that time there will be no night in that place, but the twilight will continue from ſun-ſetting to ſun-riſing; and on this account it is, that from about the 22d of May to about the 21ſt of July there is no total darkneſs at London, the ſun's declination during that interval being greater than 20° 28′, which is the difference between 18° and 38° 28′, the complement of the latitude.

996. PROBLEM XIII.

Given the time of the year, the latitude of a place, and the altitud
a known fixed ſtar;

Required the hour of the night when the obſervation was made.

EXAM. *Some time in the night, on the 27th of November,* 1752, *the Arcturus was obſerved at London to be* 27° 12′ *above the horizon: At hour was the ſtar obſerved?*

CONSTRUCTION.

Deſcribe the meridian of the place, draw the horizon HR, whoſe ze and nadir are Z and N, and deſcribe (10th 968) the parallel of altitude *r* 27° 12′ above the horizon; take P the north pole 51° 32′ above the rizon for the latitude of the place, and S the ſouth pole as much be the horizon; draw the equator EQ, and deſcribe (3d 968) the ſtar's par of declination *n m*, found in the table, art. 1054, to be 20° 30′ N.; where this parallel *n m* cuts the former *r s* in ∗, is the poſition of ſtar at the time of obſervation; deſcribe (163) the vertical circle Z and hour circle P ∗ S, and the angle ZP∗ being meaſured (448), gives hour from noon.

COMPUTATION.

In the oblique angled ſpheric triangle P∗Z.

Given the co-lat. PZ = 38° 28′
the co-altitude Z∗ = 62 48
the polar diſt. ∗P = 69 30
Required ∠ZP∗, or the from noon.

Here P∗ = 69° 30′
PZ = 38 28
Z∗ = 62 48
P∗ − PZ = 31 02 = D.
93 50 | 46° 55′
2) 31 40 | 15 53

Then Co-ar. ſin. co-lat. = 38° 28′ 0,2
Co-ar. ſin. pol. diſt. = 69 30 0,0
Sin ½ ſum zen. diſt. and D = 46 55 9,8
Sin ½ diff. zen. diſt. and D = 15 53 9,4

The ſum of the four logs. 19,5

The ½ ſum gives 35° 51′ 9,7

Which doubled, gives 71° 42′ = ∠ZP∗.

This 71° 42′ turned into time (960) gives 4 h. 46 m. 48 ſ. for the which muſt elapſe before the ſtar comes to the meridian.

Now, at the time of obſervation, November 27th, 1752,

	h	m
The ſun's right aſcenſion, found in table, art. 1053, is	16	13
The ſtar's right aſcenſion, found in table, art. 1054, is	14	03
difference of right aſcenſions	2	10
	12	00
The ſtar ſouths, or culminates	9	50
The time the ſtar has to come to the meridian	4	47
The difference gives the hour of the night	5	03 P.
Or, the ſum gives the hour after midnight	14	37

Which is 2 h. 37 m. in the morning.

And whether to ſubtract or add, will always be known by the being in the eaſtern part of the horizon, or aſcending; or by bein the weſtern part of the horizon, or deſcending.

PROBLEM XIV.

97, Given the obliquity of the ecliptic, and a ſtar's right aſcenſion and declination;

Required its latitude and longitude.

Exam. *What is the latitude and longitude of a ſtar, its right aſcenſion* ng 16 *h.* 14 *m., its declination* 25° 51′ *S., and the obliquity of the ecliptic* 2 29′*?*

Construction.

Let the primitive circle repreſent the ſolſtitial colure, in which draw th equator EQ, mark its poles P, S, and deſcribe (3d 968) the parallel of th ſtar's declination *nm*.

The right aſcenſion 16 h. 14 m. = 243° 30′, which being 63° 30′ ve 180°, falls in the third quadrant; therefore make (451) ♈ *a* = 6 30′, deſcribe (4th 968) the circle of right aſcenſion, cutting the parallel in *, the point of the heavens repreſenting the ſtar.

Make E♋ = 23° 29′, the obliquity of the ecliptic, draw the ecliptic , find its poles *pq*, and thro' *p***q* deſcribe a circle of longitude; n the arc *p** meaſured (446) will give the co-latitude, and the ∠*p** will ſhew the longitude.

Computation.

In the oblique angled ſpheric triangle *p*P*.

Given the oblique ecliptic *p*P = 23° 29′
the co-declination P* = 64 09
the right aſcen. ∠*p*P* = 153 30

Required the co-lat. *p**.
and the longit. ∠P*p**.
See art. 534, 533.

To find the latitude.

A Radius	=	R	10,00000
cof. rt. aſc.	=	153°30′	9,95179
an. ob. ecl.	=	23 29	9,63796
tan. 4th arc	=	21 15	9,58975
ſup. = 4th arc	=	158 45	
which take		64 09	= co-decl.
es a 5th arc	=	94 36	

As coſ. 4th arc	=	158° 45′	0,03058
To coſ. 5th arc	=	94 36	8,90417
So coſ. obl. ecl.	=	23 29	9,96245
To ſin. lat.	=	4 32	8,89720

Here the latitude of the ſtar is 4° 32′ N. becauſe the declination is north, and the co-lat. reckoned from the N. pole is leſs than 90°.

To find the longitude.

ſin. co-lat.	=	85° 28′	0,00136
in co-decl.	=	64 09	9,95421
n. rt. aſcen.	=	153 30	9,64953
coſ. longit.	=	23 45	9,60510

Here the co-longitude 23° 45′ taken from 270° leaves 246° 15′ for the ſtar's longitude, reckoning from the firſt point of Aries.

ecauſe the right aſcenſion being in the third quadrant, the ſtar is the alſo.

ow in 246° 15′ are 8 ſigns, 6 deg. 15 min.; that is, the ſtar's place, ongitude, is 6° 15′ in the 9th ſign, or 6° 15′ in ♐.

98. By the preceſſion of the equinoxes, the fixed ſtars, altho' they ways keep the ſame latitudes, yet they are continually altering their longitude, right aſcenſion and declination; the alteration in longitude is uniformly 50 ſeconds yearly (848), but that of the right aſcenſion and declination is conſtantly varying: So that many ſtars, which once had north ec, come to have ſouth; while others change from S. to N. decl.

999. PROBLEM XV.

Given the right aſcenſions and declinations of two fixed ſtars; Required their diſtance.

Exam. *What is the diſtance between the fixed ſtars, Algol in the hea Meduſa, and Aldebaran in Taurus; the former having* 39° 59′ *N. a with* 2 *h.* 52 *m. right aſcenſion; and the other* 15° 59′ *N. decl., with* 22 *m. of right aſcenſion.*

Construction.

As Aldebaran precedes Algol in right aſcenſion, let the primitive ci repreſent the circle of right aſcenſion paſſing thro' Aldebaran; deſc the circle of right aſcenſion PAS, making with PBS an angle of 22° (451) equal to the difference between the given right aſcenſions.

Deſcribe the parallels of declination B *m*, *r s*, at the given diſtances 59′ N., and 39° 59′ N. (3d 968); and the interſections B, of Aldebar declination, and A, of Algol's, with their reſpective circles of right cenſion, will be the poſitions of thoſe ſtars from one another: The great circle BAC, paſſing thro' B and A, the intercepted arc BA (meaſu by art. 446) ſhews the diſtance of thoſe two ſtars.

Computation. (5

In the oblique angled ſpheric triangle PAB.

Given the co-decl. of Ald. PB = 74° 01′
the co-decl. of Algol. PA = 50 01
diff. of right aſcen. ∠APB = 22 30
} Required their diſt..

As Radius	= R	10,00000	From 4th arc	=	72°
To coſ. diff. rt. aſ.	= 22°30′	9,96562	Take Algol's co-decl.	=	50
So cot. Aldeb. dec.	= 15 59	10,54298			
			Remains 5th arc	=	22
To tan. 4th arc	= 72 47	10,50868			

And as coſ. 4th arc	= 72 47	0,52873
To coſ. 5th arc	= 22 46	9,96477
So ſin. Aldeb. decl.	= 15 59	9,43990
To coſ. diſtance	= 30 56	9,93340

The ſame reſult would have co out, had the declination of the Algol been uſed in the proportio

1000. PROBLEM XVI.

Given the latitudes and longitudes of two known fixed ſtars; Required their diſtance.

Exam. *Aliath, in the Great Bear,*	*Lon.* ♍ 4° 55′.	*Lat.* 54° 18′
Arcturus, in Bootes,	*Lon.* ♎ 20 15.	*Lat.* 30 57

The conſtruction of this problem is like that of the laſt; only inſt of circles of right aſcenſion, read circles of longitude, and uſe parall of latitude inſtead of parallels of declination.

The computation is alſo like that of the laſt, there being given t co-latitudes and the included angle, which is the difference between given longitudes: Thus Arcturus's long. is 6ſ 20° 15′, and Aliath's 5ſ 4° 55′; their difference is 1ſ 15° 20′, or 45° 20′.

Hence the diſtance will be found to be 39° 42′.

10

001. PROBLEM XVII.

Given the latitude and longitude of a fixed ſtar, and alſo the obliquity of the ecliptic;

Required the right aſcenſion and declination of that ſtar.

EXAM. *Suppoſe the latitude of a ſtar is 7° 09′ N., its longitude 29° 01′: Vhat is the right aſcenſion and declination of that ſtar, the obliquity of the liptic being 23° 29′?*

The conſtruction of this problem is much like that of Prob. XIV.; nly here the interſection of a parallel of latitude *c b* with a circle of ngitude *p* A *q*, will give the place of the ſtar.

The computation is alſo as in Prob. XIV.; for here are given P*p* = 3° 29′, *p* A = 82° 51′, and the ∠P*p* A = 60° 59′, the co-longitude: o find PA the co-declination, and ∠*p* PA the right aſcenſion.

The declination of the ſtar will be found to be 17° 49′ N.

And the right aſcenſion will be 114° 18′: But as the ſtar's place is in e firſt quadrant of the ecliptic, its right aſcenſion muſt be in the firſt uadrant of the equator; therefore 24° 18′ is the right aſcenſion reckoned om Aries.

002. PROBLEM XVIII.

Given the meridional altitude of any celeſtial object, ſuppoſe a comet; its diſtance from a known ſtar; and the latitude of the place;

Required the declination and right aſcenſion of that comet.

EXAM. *Suppoſe a comet was obſerved on the meridian at London, when s altitude was 51° 55′, and its diſtance from the ſtar Arcturus was 59° 7′: What was the declination and right aſcenſion of the comet at that time?*

CONSTRUCTION.

In the primitive circle, repreſenting the meridian of the place, draw e horizon HR and prime vertical ZN; lay off the given latitude RP = 1° 32′, draw the axis PS, the equator EQ, and (3d 968) *n m* Arcturus's rallel of declination = 20° 30′. From the ſouth point of the horizon y off the given altitude of the comet = 51° 55′ from H to O: About e point O as a pole, at the given diſtance between the comet and Arcrus, deſcribe (456) a ſmall circle *a a* cutting the parallel *n m* in ∗, e poſition of Arcturus at that time: Deſcribe the circle of right aſcenon P ∗ S, and a great circle thro' O and ∗.

COMPUTATION.

Since HE = 38° 28′, the co-lat., and the alt. HO = 51° 55′, then EO = IO — HE =) 13° 27′, is the decl. ſought; which is north as the altitude ceeds the co-lat.; conſequently the polar diſtance OP = 76° 33′.

Then in the triangle P ∗ O are given the three ſides to find the ∠OP ∗, e difference between the right aſcenſions of the comet and Arcturus. nd (537) the ∠OP ∗ will be found = 62° 27′ = 4 h. 9 m. 48 ſ. which the difference of their right aſcenſions: Now if Arcturus precedes the met, the right aſcenſion of the latter is 9 h. 53 m. 12 ſ.: But if the met precedes, its right aſcenſion is 18 h. 12 m. 48 ſ., the former being e diff., and the latter the ſum of the right aſcenſions of Arcturus and the met.

1003. PROBLEM XIX.

Given the latitude of a place, the ſun's declination and azimuth; Required his altitude and the time of the obſervation.

Exam. *In the latitude of* 13° 30′ *N., and when the ſun has* 23° 2 *N. declination: What is the ſun's altitude and time of the day, when he ſeen on the ENE. azimuth circle?*

Construction.

Let the primitive circle repreſent the meridian of the place, wherei HR repreſents the horizon, and ZN the prime vertical; make RP equ to the latitude, draw the 6 o'clock hour circle PS, the equator EQ, an (3d 968) the parallel of 23° 29′ of declination *n m*: The tangent of 6 30′ being laid from the centre *a* towards H, gives the centre of the ve tical circle ZDN, which cuts the parallel *n m* in the points A and B; an ſhews that at two diſtant times in the forenoon the ſun will have t azimuth propoſed: Thro' the points A and B deſcribe the hour circl PAS, PBS (163); the angles ZPA, ZPB, ſhewing the times from noo may be meaſured by art. 448; and the altitudes DA, DB, by art. 446.

Computation. See art. 529.

In the ſpheric triangle PZA, or PZB, there are known

The co-lat. PZ = 76° 30′; the co-decl. PA, or PB = 66° 31′; the azin ∠PZD = 67° 30′.

To find ZA, or ZB, and the ∠ZPA, or ∠ZPB.

As Radius : coſ. azimuth :: cot. lat. : to tan. of a 4th arc M = 57° 54′.
And as ſin. lat. : ſin. decl. :: coſ. M : to coſ. of a 5th arc N = 24° 54′.
Then M + N, or 57°54′ + 24°54′ = 82°48′ = ZA, is the comp. of leaſt al
And M — N, or 57°54′ — 24°54′ = 33°00′ = ZB, is the comp. of greateſt a
Therefore, when the ſun has 7° 12′, or 57° 00′ of alt. he is on the giv. azir
Again. As coſ. decl. : ſin. azim. :: coſ. leaſt alt. : ſin. hour fr. noon 88°02
And as coſ. decl. : ſin. azim. :: coſ. greater alt. : ſin. hour fr. noon 33°1
But 88° 02′ = 5h 52m; and 33°16′ = 2h 13m, the reſpect. times fr. noo

Conſequently the ſun will be ſeen on the ENE. azimuth at 6 h. 08 m and again at 9 h. 47 m., both in the morning: Alſo, in the afternoon l will be on the WNW. azimuth at 2 h. 13 m., and at 5 h. 52 m.

1004. Now to find at what time, and at what altitude, the greate azimuth will happen at that place on the ſaid day.

As the azimuth circle in this caſe is to touch the parallel *n m*, ther fore the greateſt diſtance of the azimuth from the equator will be 23° 29 and as their poles muſt be at the ſame diſtance (413), therefore a ſma circle *r s* deſcribed about the pole S, at the diſtance of 23° 29′ (454 its interſection *p* with the horizon, is the pole of the circle ZCN; th deſcribe an hour circle PCS thro' *p*.

In the ſpheric triangle ZPC right angled at C. (41

Given the co-lat. PZ = 76° 30′, and the co-decl. PC = 66° 31′.

Required the greateſt azim. ∠PZC = 70° 36′, the diſt. ZC = 54° 0 and the hour from noon = 56° 27′ = 3 h. 46 m.

1005. So that the azimuth is altered only 3° 6′ in 1 h. 33 m.; a conſequently the variation of the compaſs in the torrid zone may be o ſerved more accurately than elſewhere, could the altitudes when ne the zenith be well taken.

SECTIO

SECTION VI.

006. *Of various methods to find the latitude.*

The uſual way at ſea to find the latitude, is from the ſun's meridional titude and declination; the manner of doing this will be particularly ıewn in the next book: But as it frequently happens at ſea, that the eridian altitude cannot be taken, therefore the mariner ſhould be fur-ſhed with other means to come at this moſt uſeful knowledge of his titude: To help him in this point, and as a farther exerciſe in the ſtronomy of the ſphere, the following problems are collected together.

07. PROBLEM XX.

Given the ſun's declination and his amplitude;
Required the latitude of the place.

EXAM. *Being in a place where the compaſs had no variation, on the firſt May*, 1753, *I obſerved the ſun to riſe* 62° 30′ *from the north towards the ſt: Required the latitude of that place?*

CONSTRUCTION.

Having deſcribed the primitive circle, drawn the horizon HR, and 47) taken RO = 62° 30′; then about O as a pole deſcribe (454) a ıall circle, at the diſtance of 74° 48′ = co-decl., cutting the primitive P the place of the north pole: Draw the axis PS, the equator EQ, d the circle POS, cutting the equator in A.

COMPUTATION.

In the ſpheric triangle ♈OA right angled at A.

iven the co-amp. ♈O = 27° 30′	Then ſ.♈O : Rad :: ſ.AO : ſ.∠A♈O.
the declin. AO = 15 12	Hence the latitude will be 55° 24′
equired the co-latitude A♈O.	N.

08. PROBLEM XXI.

Given the ſun's declination, and his aſcenſional difference;
Required the latitude of the place.

EXAM. *On the* 20th *of January*, 1753, *the ſun was obſerved to ſet at h.* 30 *m.: Required the latitude of the place?*

As the aſcenſional difference is the time the ſun riſes or ſets before or er 6 o'clock; therefore 6 h. — 4 h. 30 m. = 1 h. 30 m. = 22° 30′ = enſional difference.

CONSTRUCTION. In the primitive circle repreſenting the meridian of the place, draw the equator EQ, the axis PS, the parallel of declination ro, 20° 01′ S.: Make ♈B = 22° 30′, the aſcenſional difference; de-ſcribe the circle of right aſcenſion PBS, cutting *ro* in O; then a diameter R thro' O will be the horizon, and R*p* the lat. ſought.

COMPUTATION. In the ſpheric triangle ♈BO, right angled at B.

Given the aſ. diff. ♈B = 22° 30′	Then Rad : cot. OB :: ſ. ♈B : cot. ∠O♈B.
the declin. OB = 20 01	Or Rad : cot. decl. :: ſin. rt. aſ. : tan. lat.
equired the co-lat. ∠O♈B.	Hence the lat. will be 46° 25′ N., be-

ing contrary to the declin. when the aſcen. diff. falls between noon and ſix.

1009. PROBLEM XXII.

Given the ſun's declination, and altitude at ſix o'clock;

Required the latitude of the place.

EXAM. *Being at ſea on the 20th of May*, 1753, *at ſix o'clock in the eve ing, the ſun's altitude was* 18° 45′ *: What was the latitude of the place obſervation?*

CONSTRUCTION. Having deſcribed the meridian, drawn the horizon HI the prime vertical ZN, and the parallel *st* of 18° 45′ altitude (10th 968) from the centre ♈, with the half tangent of the declination = 20° 04 cut the parallel *st* in O: Thro' O draw the axis PS, and the azimu circle ZON (163), and the meaſure of RP will give the latitude ſought.

COMPUTATION. In the ſpheric triangle ♈AO, right angled at A.

Given the decl. ♈O = 20° 04′ N.	Then ſin. ♈O : Rad :: ſ. AO : ſ.∠O♈
the altit. AO = 18 45	Or ſin. decl. : Rad :: ſin. alt. : ſin. lati
Required the lat. = ∠O♈A.	Which is 69° 32′ N., as the decl. is N

1010. PROBLEM XXIII.

Given the ſun's declination, and altitude when he is due eaſt or weſ

Required the latitude of the place.

EXAM. *In a place where the compaſs had no variation, the ſun was o ſerved to be due eaſt when his declination was* 16° 38′ *N., and his altitu* 20° 12′ *: What is the latitude of that place?*

CONSTRUCTION. In the meridian HZRN, draw the horizon HR, th prime vertical ZN, and make ♈O = half tan. of the alt. 20° 12′: About as a pole, at the diſtance of 73° 22′, the co-decl., deſcribe (454) a ſma circle, cutting the meridian in P the elevated pole; draw the axis P equator EQ, and thro' P, O, S, deſcribe an hour circle POS; then th meaſure of PR ſhews the latitude.

COMPUTATION. In the ſpheric triangle ♈AO, right angled at A.

Given the alt. ♈O = 20° 12′	Then ſin. ♈O : Rad :: ſin. AO : ſin. ∠A♈
the decl. AO = 16 38N.	Or ſin. alt. : Rad :: ſin. decl. : ſin. lat.
Required the latit. = ∠A♈O.	Which is 56° 00′ N., as the decl. is N

But had the declination been S., the other interſection of the parall circle and meridian muſt have been taken for the elevated pole, and th latitude would be ſouth.

1011. PROBLEM XXIV.

Given the ſun's altitude and hour of the day on either equinox;

Required the latitude of the place.

EXAM. *On the day the ſun enter'd the vernal equinox, his latitude was foun* 22° 56′ *at* 9 *o'clock in the morning: In what lat. was that obſervation made*

CONSTRUCTION. Deſcribe the meridian, draw the horizon, the prin vertical, and (10th 968) the parallel *st* of 22° 56′ altitude; from the cent ♈, with the half tan. of 45° = 3 h., the aſcen. diff., cut *st* in O, an deſcribe the vertical circle ZON, cutting the horizon in B.

COMPUTATION. In the ſpheric triangle ♈BO, right angled at B.

Given the time after 6 ♈O = 45° 00′	As ſ. ♈O : Rad :: ſ. BO : ſ. ∠B♈
the altitude BO = 22 56	Or ſ. time à 6 : Rad :: ſ. alt. : coſ.
Required the co-latitude B♈O.	Which is 56° 34′.

12.

PROBLEM XXV.

Given the ſun's altitude, declination and azimuth;
Required the latitude of the place.

Exam. *June 4th, 1753, being at ſea in a place where the compaſs had variation, in the afternoon when the ſun was 42° 30′ high, his bearing s S. 57° 45′ W.: What is the latitude of that place?*

Construction. Draw the meridian, the horizon HR, the prime rtical ZN, and the parallel *s t* at 42° 30′ above the horizon (456): he tangent of 57° 45′ ſet from A towards R gives the centre of the imuth circle ZON, cutting the parallel of altitude *s t* in O: About O a pole (454), at the diſtance of 67° 30′, equal to the co-declination, ſcribe a ſmall circle, cutting the meridian in P the place of the pole; n the meaſure of RP gives the latitude ſought.

Computation. In the oblique angled ſpheric triangle ZOP.

Given the zenith diſt. ZO = 47° 30′
the polar diſt. PO = 67 30
the azimuth ∠PZO = 122 15
} Required the co-latitude PZ.

Rad	=	R	10,00000	As ſin. alt.	=	42° 30′	0,17032
coſ. azim.	=	122° 15′	9,72723	To ſin. decl.	=	22 30	9,58284
cot. alt.	=	42 30	10,03795	So coſ. 4th	=	30 13	9,93658
tan. 4th	=	30 13	9,76518	To coſ. 5th	=	60 42	9,68974

Then the difference between the 5th and 4th arcs, that is 30° 13′ ken from 60° 42′, the remainder 30° 29′ is the co-lat. Therefore 59° ′N. is the latitude ſought.

13.

PROBLEM XXVI.

Given the ſun's declination, his altitude and hour of the day;
Required the latitude of the place.

Exam. *Being at ſea, the ſun's altitude was obſerved to be 37° 20′ at h. 45 m. in the morning, his declination at that time being 20° 30′ N.: hat is the latitude of the place of obſervation?*

Construction. In the meridian PESQ, draw the equator EQ, axis , and parallel of declinat. *n m*, 22° 30′ diſt. from the equator (3d 968): t off from the centre A towards Q the tang. of 33° 45′ = 2 h. 15 m., e diſtance between the time of obſervation and noon, which gives the ntre of the hour circle POS, cutting the parallel *n m* in O: About the int O as a pole, deſcribe (454) at the diſt. of 52° 40′, the zen. diſt., ſmall circle, cutting the meridian in Z the zenith; thro' ZO deſcribe azimuth circle ZON; then the meaſure of ZE will give the lat. ſought.

Computation. In the oblique angled triangle ZOP.

Given the zenith diſtance ZO = 52° 40′
the polar diſtance PO = 67 30
the hour from noon ∠ZPO = 33 45
} Required the co-lat. ZP.

As Rad : coſ. hour A. M. : : cot. decl. : tan. 4th arc = 63° 31′.
As ſin. decl. : ſin. alt. : : coſ. 4th arc : coſ. 5th arc = 45 02.
Their difference is the co-latitude 18° 29′. Therefore the lat. is 71° ′N.

1014. PROBLEM XXVII.

Given the altitudes of two known fixed ſtars, having the ſame azir
Required the latitude of the place.

Exam. *Being at ſea in an unknown latitude, I obſerved the ſtar Schea in Caſſiopeia, and Almaach in Andromeda, to have the ſame Azimuth, wh the altitude of Schedar was* 37° 15′, *and that of Almaach was* 17° 45 *What is the latitude of that place?*

Construction *upon the plane of the equator*. Let the primitive cir repreſent the equator, whoſe pole is P, and any point ♈ the place whe the right aſcenſion begins, from whence lay off ♈ a = 27° 15′ for A maach's right aſcenſion, and ♈ b = 6° 45′ for Schedar's; draw t circles of right aſcenſion Pa, Pb: Deſcribe (3d 970) Almaach's and Sch dar's parallels of declination, cutting Pa, Pb, in A, B; A being Almaac and B Schedar. A great circle paſſing thro' A and B, will be the az muth they are on. About B at the diſtance of 52° 54′, Schedar's zeni diſtance, deſcribe (454) a ſmall circle, cutting the azimuth circle thr A and B in Z, the zenith of the place; draw PZ, which meaſured on t half tangents gives the co-latitude of the place of obſervation.

Computation.

1ſt. In the oblique angled ſpheric triangle ABP.

Given Almaach's co-dec. PA = 48° 52′
Schedar's co-dec. PB = 34 49
their diff. of alt. AB = 19 30

Required the angle of po
tion ABP.
For the ſolution ſee art. 55

PB = 34° 49′
BA = 19 30
PA = 48 52
PB − BA = 15 19
64 11 | 32° 05½′ = ½ ſum.
33 33 | 16 46½′ = ½ diff.

Co-ar. ſin. PB = 34° 49′ 0,243
Co-ar. ſin. BA = 19 30 0,476
Sin. ½ ſum = 32 05½ 9,725
Sin. ½ diff. = 16 46½ 9,460
Sum of four logs. 19,9055
½ ſum gives 63° 45½′ 9,9527
Which doub. gives 127° 31′ = ∠ AB

2d. In the oblique ſpheric triangle PBZ.

Given Schedar's co-dec. PB = 34° 49′
Schedar's co-alt. BZ = 52 45
angle of poſition PBZ = 52 29

Required the co-lat. PZ.
For the ſolution ſee art. 54
Here ∠PBZ = ſuppl. ∠PB

As Rad = R 10,00000
To coſ. ∠ poſit. = 52° 29′ 9,78461
So cot. Sch. decl. = 55 11 9,84227
To tan. 4th arc = 22 57 9,62688
Which taken from 52 45 = BZ.
Leaves 5th arc 29 48

As coſ. 4th arc = 22° 57′ 0,0358
To coſ. 5th arc = 29 48 9,9384
So ſin. Sch. decl. = 55 11 9,9143
To ſin. latit. = 50 41 9,8885

115. PROBLEM XXVIII.

Given the difference of time between the riſing of two known ſtars; Required the latitude of the place.

EXAM. *Being at ſea in an unknown place, the ſtar Aldebaran was ob- ſved to riſe 3 h. 15 m. later than the bright ſtar in Aries: Required the itude of that place?*

Bright ſtar in ♈ decl. 22° 17′ N.; right aſcen. 1 h. 53 m. Aldeba- n's decl. 15° 59′ N.; right aſcenſion 4 h. 22 m.

CONSTRUCTION.

Let the primitive circle repreſent the equator, deſcribe (3d 970) the pallels of declination of the two ſtars, that of Aries being 22° 17′ N., ad of Aldebaran 15° 59′ N.: Draw P *a* for the circle of right aſcenſion pſing thro' the ſtar in ♈, which ſuppoſe in A: From *a* lay off *a b* = ° 15′ = diff. of right aſcenſions; and *a c* = 48° 45′ = 3 h. 15 m., the df. of time between their riſing; draw *b* P, *c* P, cutting the parallels of dlination in B, C: Thro' the points B, C, deſcribe (441) the great rcle HOR; draw PO at right angles to HR, then the meaſure of PO will ge the latitude ſought.

COMPUTATION.

In the oblique angled ſpheric triangle PBC.

Given B's co-decl. PB = 74° 01′	Rad : coſ. ∠BPC : : t. PB : t. M = 73° 42′.
A's co-decl. PC = 67 43	From M take PC leaves N = 5 59.
∠APC − ∠APB = ∠BPC = 11 30	As ſin. N : ſ. M : : tan. ∠CPB : t. ∠C =
Required the angle PCB.	Hence ∠PCO = 61° 54′. [118° 06′.

In the ſpheric triangle PCO, right angled at O.

Given C's co-decl. PC = 67° 43′	As Rad : ſin. PC : : ſin. ∠PCO : ſin. PO
and the ∠PCO = 61 54	[= 54° 43′.
Required the latitude PO.	Therefore the latitude is 54° 43′.

116. PROBLEM XXIX.

Two known fixed ſtars being obſerved to have the ſame altitude; Required the latitude of the place of obſervation.

EXAM. *In the evening, the ſtars Capella and Procyon were obſerved at t ſame time to have each 38° 00′ of altitude: Required the latitude of the ce where that obſervation was taken?*

Capella's decl. = 45° 43′ N. right aſcen. 4 h. 59 m. Procyon's decl. = 5° 49′ N. right aſcen. = 7 h. 24′.

CONSTRUCTION.

On the plane of the equator, repreſented by the primitive circle, de- ſcbe (3d 970) the parallels of the given declinations; take *a b* = 36° 15′, t diff. of the given right aſcenſions; draw P *a*, P *b*, then A repreſents Pocyon, and B Capella.

About A and B as poles, deſcribe (454) arcs of ſmall circles, at the dance of 52°, the co-altitude, and their interſection gives Z the zenith o the place: Thro' the points A, B; Z, A; Z, B; deſcribe great circles (441), and draw ZP, whoſe meaſure will give the co-latitude of the place o obſervation.

COMPUTATION.

In the oblique angled ſpheric triangle APB.

Given A's co-decl. AP = 84°11′
B's co-decl. BP = 44 17
diff. rt. aſc.∠ABP = 36 15
Required the ſtars diſtance AB.
And the angle BAP.

Rad : coſ.∠P : : t.BP : t.M = 38°1
And M tak. fr. PA leaves N = 46 0
Sin.N : ſin.M : : tan.∠P : tan.∠B.
[= 32°1
Coſ.M : coſ N : : coſ.BP : coſ.BA = 50 4

In the oblique angled ſpheric triangle AZB.

Given A's co-alt. ZA = 52°00′
B's co-alt. ZB = 52 00
ſtars diſtance AB = 50 45
Required the angle ZAB.

The angle BAZ will be found 68° 15′.
Then ∠BAZ — ∠BAP = ∠PAZ
36° 02′.

In the ſpheric triangle AZP.

Given A's co-alt. ZA = 52° 00′
A's co-lat. AP = 84 11
the angle ZAP = 36 02
Required the co-lat. ZP.

Rad : coſ.∠A : : t.ZA : t.M = 45°5
M taken from PA leaves N = 38 1
Coſ.M : coſ.N : : coſ.ZA : coſ.PZ = 45 5
Therefore the latitude is 44° 08′

1017. PROBLEM XXX.

Given the altitudes of two known fixed ſtars;
Required the latitude of the place.

EXAM. *The altitude of the Hydra's heart was obſerved to be* 40° 4 *and of the Lion's heart* 45° 00′ : *What is the latitude of the place of obſ vation ?*

Hydra's heart, decl. = 7° 37′ S.; right aſcen. = 9 h. 16 m. Lio heart, decl. = 13° 09′ N.; right aſcen. 9 h. 53 m.

CONSTRUCTION.

If this problem is conſtructed on the plane of the equator, it will in every reſpect like the laſt; only the ſmall circles, deſcribed about and B, are to be unequally diſtant from their reſpective poles A, B.

COMPUTATION.

Here, as in the laſt, there will be three ſpheric triangles to work i namely, the triangles APB, ZAB, and ZPB.

In the triangle APB, where AP = 97° 37′, BP = 76° 51′, ∠APB 9° 15′.

As Rad : coſ.∠APB : : tan. BP : tan. M = 76° 41′. Then AP — M = = 20° 56′.

As ſin. N : ſin. M : : tan. ∠APB : tan. ∠BAP = 23° 55′.

And as coſ. M : coſ. N : : coſ. BP : coſ. BA = 22 42.

In the triangle BAZ, where AZ = 49° 16, BZ = 45° 00′, AB = 22°4
The angle BAZ will be found equal to 68° 56′. (5
Then ∠BAZ — ∠BAP = ∠PAZ = 45° 01′.

In the triangle APZ, where AP = 97° 37′, AZ = 49° 16′, ∠PAZ = 45°
As Rad : coſ.∠PAZ : : tan. AZ : tan. M = 39° 23′. Then AP — M N = 58° 14′.
And as coſ. M : coſ. N : : coſ. AZ : coſ. PZ = 63° 23′.
Hence the latitude ſought is 63° 23′ N.

018.

PROBLEM XXXI.

Given the ſun's declination, two altitudes, and the time between the obſervations ;
Required the latitude of the place.

Exam. *On a day when the ſun's declination was* 20° 00′ *N., in the fore-on the ſun's altitude was obſerved to be* 18° 30′, *and three hours after, his titude was* 44° 00′ *: What was the latitude of the place?*

Construction.

Let the primitive circle repreſent that hour circle on which the ſun was the firſt obſervation, EQ being the equator, then A *a*, the parallel of ° of declination, gives A the ſun's place at firſt ; and as CQ is the tan-nt of 45°, Q will be the centre of the hour circle PBS three hours di-ant from the former, its interſection B with the parallel of declination, the ſun's place at the ſecond obſervation : About A as a pole, at the ſtance of 71° 30′, the firſt zenith diſtance, deſcribe (454) a ſmall circle ; out B as a pole, at the diſtance of 46° 00′, the ſecond zenith diſtance, ſcribe (454) another ſmall circle, cutting the former in Z the zenith : hro' Z, A ; Z, B ; A, B ; P, Z ; deſcribe (441) great circles ; then PZ the co-latitude required.

Computation.

Here are three triangles to work in ; namely, ABP, ABZ, BPZ.

In the iſoſceles ſpheric triangle APB.

Given AP = 70° 00′	Suppoſe a perpendicular P*b* is drawn.
BP = 70 00	Rad : tan. BP*b* : : coſ. PB : cot. ∠PBA = 81° 56′.
∠APB = 45 00	Rad : ſin. PB : : ſin. ∠BP*b* : ſin. B*b* = 21° 04½′.
Req. ∠ABP and AB.	Then B*b* doubled gives AB = 42° 09′.

In the oblique angled ſpheric triangle ABZ.

Given AZ = 71° 30′	Then working by art. 537 for three ſides, the angle ABZ will be found = 114° 11′.
BZ = 46 00	And ∠ABZ — ∠PBA = PBZ = 32° 15′.
AB = 42 09	
Required ∠ABZ.	

In the oblique angled ſpheric triangle PBZ.

Given PB = 70° 00′	As Rad : coſ. ∠PBZ : : tan. BZ : tan. M = 41° 13′.
BZ = 46 00	And PB — M = N = 28° 47′.
∠PBZ = 32 15	As coſ. M : coſ. N : : coſ. BZ : coſ. PZ = 35° 58′.
Requir. the co-lat. PZ.	Therefore the latitude is 54° 02′ N.

1019. If the ſun's altitude can be taken both before and after noon, hen he has equal heights, then the time between theſe two obſervati-s being biſected, will give the time when the ſun was on the meridian : ow the co-declination, the co-altitude, and the time from noon at either obſervation being known, the latitude may be readily computed in e oblique angled triangle, wherein are known two ſides, and an angle poſite to one of them to find the other ſide, which is the co-latitude ; which ſee the problem, art. 1013.

1020. PROBLEM XXXII.

Given the ſun's declination, two altitudes, and the difference of th magnetic azimuths;

Required the latitude of the place.

EXAM. *On the 21ſt of May, the ſun's declination being 20° 16′ N., i the morning when the ſun was on the ESE. point of the compaſs, his altitu was 43° 30′; and when he bore S. 20° 30′ E. his altitude was 58° 30′ What is the latitude of the place of obſervation?*

CONSTRUCTION.

Let the primitive circle repreſent the azimuth circle the ſun was on a the greateſt altitude 58° 30′, A being the ſun's place at that time, H the horizon, and Z the zenith; draw *a a* a parallel of 43° 30′ of altitud and (451) deſcribe a vertical circle, making an angle with AZ, of 47 00′, the diff. of the obſerved azimuths; where this cuts the parallel o altitude *a a*, gives B the ſun's place at the firſt obſervation: Then ſma circles being deſcribed about A and B, as poles, at the diſtances of 6 44′, the co-declination (454), their interſection will give P the place o the pole: Thro' A, B; P, A; P, B; and Z, P, deſcribe great circle (441); then PZ is the co-latitude ſought.

COMPUTATION.

1ſt. In the ſpheric triangle AZB: Given AZ = A's co-alt. = 31° 3
BZ = B's co-alt. = 46 3
∠AZB = diff. of az. = 47 0

Required ∠ABZ = 45 4
AB = 32 1

2d. In the ſpheric triangle APB: Given AP = A's co-decl. = 69 4
BP = B's co-decl. = 69 4
AB = diſtance = 32 1

Required ∠ABP = 83 5

3d. In the ſpheric triangle ZBP: Given BZ = B's co-alt. = 46 3
PB = B's co-decl. = 69 4
∠ZBP = 38 1

Requir. ZP = co-lat. = 39 2

Therefore the latitude of the place is 50° 39′ N.

1021. PROBLEM XXXIII.

Two known ſtars being obſerved on the ſame azimuth, and two oth known ſtars being obſerved on another azimuth, and the time betwee the obſervations being known; to find the latitude of the place.

EXAM. *The ſtars Aldebaran in Taurus, and Regel in Orion, were ob ſerved on the ſame azimuth; and 2 h. 35 m. after, the ſtars Caſtor in G mini and the Hydra's heart were alſo obſerved on another azimuth: Wh was the latitude of the place of obſervation?*

Con

CONSTRUCTION.

On the plane of the equator put the ſtars Aldebaran and Regel at A; , alſo the ſtars Caſtor and Hydra at *c*, *d*, by the means of their right cenſions and declinations (2d and 3d of 970): Let the ſtars *c*, *d*, be oved forwards $2^h\ 35^m$, or 38° 45′ to C, D; thro’ A, B, and D, C, deſcribe 41) great circles interſecting in Z, the zenith of the place; draw the eat circles AC and PZ; then the meaſure of PZ gives the co-latitude required.

COMPUTATION.

Aldebaran’s declin.	=	15° 59 N.	right aſcen.	= $4^h\ 22^m$	=	65° 30′.
Regel’s	=	8 28 S.		= 5 01	=	75 15.
Caſtor’s	=	32 24 N.		= 7 17	=	109 15.
Hydra’s heart	=	7 37 S.		= 9 16	=	139 00.

1ſt. In the triangle PAB, where PB = 98° 28′, PA = 74° 01′, ∠APB = 9° 15′.
Then the ∠PAB will be 157° 46′, and the ∠PAZ, the ſupl. = 22° 14′.

2d. In the triangle PCD, where PD = 97° 37′ PC = 57° 36′, ∠CPD = 29° 45′.
Then the ∠PCD will be 139° 21′, and the ∠PCZ, the ſupl. = 40° 39′.

3d. In the triangle APC, where AP = 74° 01′, CP = 57° 36′, ∠APC = 5° 00′, which is the difference between 2 h. 25 m. and the difference the right aſcenſions of A and *c*.
Then the ∠PAC will be 14° 06′, ∠PCA = 163° 23′, and AC = 16° 57′.
Now ∠PAC + ∠PAZ = ∠CAZ = 36° 20′; and ∠PCA − ∠PCZ = ACZ = 122° 44′.

4th. In the triangle ACZ, where AC = 16° 57′; ∠CAZ = 36° 20′; ACZ = 122° 44′.
Then CZ will be found equal to 24° 58′.

5th. In the triangle CPZ, where CZ = 24° 58′, CP = 57° 36′, ∠PCZ = 40° 39′.
Then PZ will be found equal to 40° 52′.
And the latitude of the place of obſervation is 49° 08′ N.

There might be given a great variety of other problems to find the itude from various circumſtances; but the trouble of ſolving them, well as ſome of the foregoing ones, is too great to render them of neral uſe: And indeed, ſome of them were only inſerted as trigonoetrical exerciſes for young ſtudents; it being generally allowed, that ſciences are moſt readily learned by working of many examples: d on this account it was judged, that the few following queſtions ght not be unentertaining to thoſe who have a love for theſe matters.

SECTION VII.

Miſcellaneous Problems.

1022. PROBLEM XXXIV.

In the latitude of 20° 00′ *N. ſtands a horizontal dial, whoſe gnomon is perpendicular to the plane of the horizon: It is required to know at what hour in the afternoon, on the* 21*ſt of June* 1753, *the ſhadow of that gnomon ſhall ſtand ſtill; and how many degrees ſhall the ſhadow run back?*

Construction. Let the circle zrnh be the meridian of the place, hr the horizon, whoſe poles are z, n; rp = 20°, the latitude, p and s the north and ſouth poles: About p deſcribe the parallel of decl. *a a*, cutting the horizon in l; about s a ſmall circle, being deſcribed at the diſt. of 23° 29′, its interſection *p* with the horizon, is the pole of the azimuth circle which will touch the parallel *a a* in ⊙, the place of the ſun when he has the greateſt azimuth that day: Thro' z, ⊙, n, deſcribe a vertical circle cutting the horizon in k; and thro' ⊙ and l deſcribe the hour circles p⊙s, pls.

Then will the ∠zp⊙ be equivalent to the hour when the ſhadow will ſtand ſtill; and kl, the difference between the meaſures of the azimuth and amplitude, will ſhew how much the ſhadow will run back.

Computation. In the right angled ſpheric triangle prl.
Given ∠r = 90° 00′
lat. = rp = 20 00
co-dec. = pl = 66 31
Requir. ampl. = rl = 64 55

In rt. angl. ſpheric triangle p⊙z.
Given ∠⊙ = 90° 00′
co-lat. = zp = 70 00
co-decl. = p⊙ = 66 31
Required hour = ∠zp⊙ = 33 06
azim. = ∠⊙zp = 77 26

Then 33° 06′ = 2 h. 12 m. 24 ſ.: And 77° 26′ — 64° 55′ = 12° 31′.

So that the ſhadow will ſtand ſtill at 2 h. 12 m. 24 ſ., and will run back 12° 31′.

1023. PROBLEM XXXV.

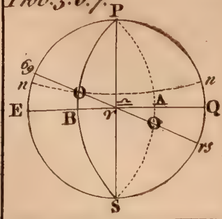
A comet, whoſe declination was 47° 00′ *N., was obſerved to be diſtant from a ſtar to the eaſtward* 49° 00′; *the ſtar's declination was* 36° 00′ *N., and its right aſcenſion* 45° 00′: *What was the latitude and longitude of that comet?*

Construction.

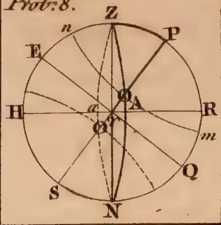
On the plane of the ſolſtitial colure, where p and e are the poles of the equator and ecliptic, put the ſtar at a by its right aſcenſion and declination: About p and a deſcribe ſmall circles, at the diſtances of the comet from thoſe points, their interſection c gives the place of the comet; deſcribe great circles thro' ac, pc, ec, then ec will be the co-latitude, and the ∠pec the co-longitude; and their meaſures may be obtained from articles 446, 448.

ASTRONOMY Pl:X.

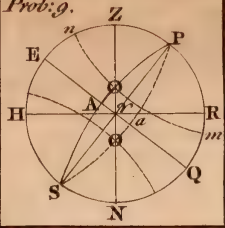
Prob:5.6.7.



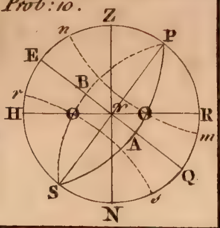
Prob:8.



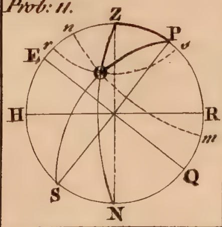
Prob:9.



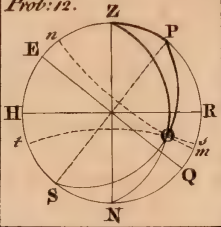
Prob:10.



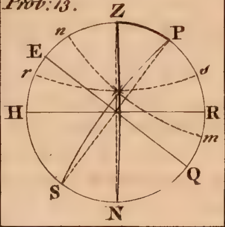
Prob:11.



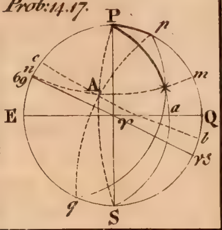
Prob:12.



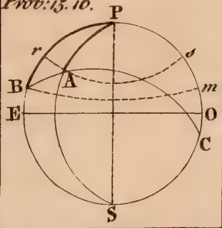
Prob:13.



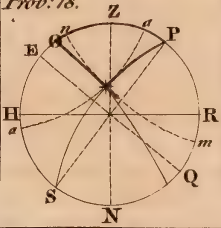
Prob:14.17.



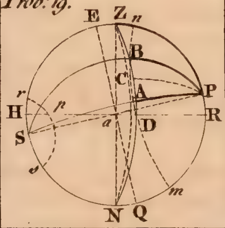
Prob:15.16.



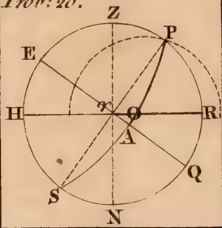
Prob:18.



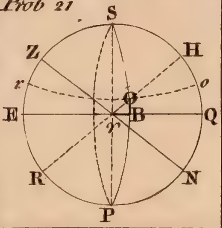
Prob:19.



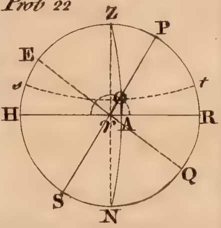
Prob:20.



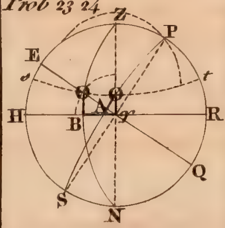
Prob 21



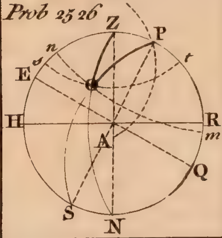
Prob 22



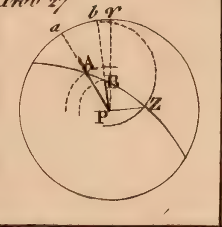
Prob 23 24



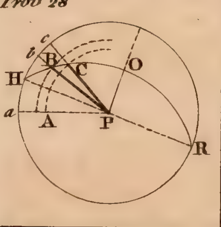
Prob 25 26



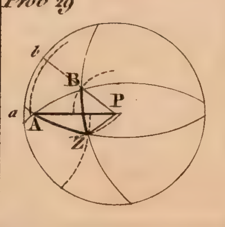
Prob 27



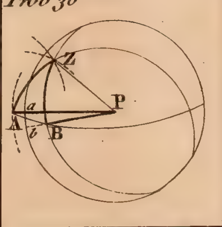
Prob 28



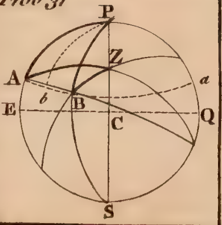
Prob 29



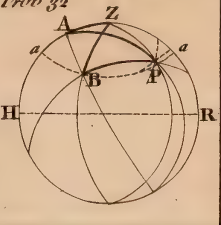
Prob 30



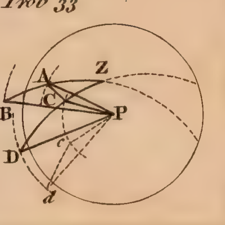
Prob 31



Prob 32



Prob 33



The Problems belonging to this plate fall between the pages 461. 484. The figures to the last 7 Astron!. Problems are in Plate XI.

T. Jefferys sculp.

Computation. In the triangle APC.
Given the ✱'s co-decl. PA = 54°00′
comet's co-decl. PC = 43 00
their diſtance AC = 49 00
Req. com. rt. aſc. fr. ✱ ∠APC = 65 48
Then 65° 48′ — 45° 00′ = 20° 48.
And 90° 00′ — 20° 48 = 69° 12′ = CPE.

In the triangle EPC.
Given comet's co-decl. PC = 43°00′
obliq. of ecliptic PE = 23 29
comet's rt. aſc. ∠EPC = 69 12
Req. comet's co-lat. EC = 39 53
and longit. ∠PEC = 83 47
Which being in the 4th quadrant, gives 23° 47′ in ♓.

1024. PROBLEM XXXVI.

At London, on the 10th of December, 1753, at what time of the night will the ſtars Aldebaran and Regel be on the ſame azimuth circle?

Aldeb. decl. = 15° 59′ N.; right aſc. = 4 h. 22 m. Regel's decl. = 8° 28′ S.; right aſc. = 5 h. 01 m.

Their difference of right aſcenſions is 39 min., or 9° 45′.

Construction. On the plane of the equinoctial put Aldebaran at A, and Regel at B, by their right aſcenſions and declinations, then a great circle thro' B and A will be the azimuth they are on at the time ſought; and the parallel of London's lat. deſcribed about P, will cut the azimuth circle BA in zz the zenith, thro' which draw the meridians PZ, PZ.

Here the neareſt interſection to the ſtars is taken for the zenith; for as the ſtars are both above the horizon, the greateſt zenith diſtance is leſs than 90 degrees.

Computation. In the △APB.
Given B's co-decl. PB = 98° 28′
A's co-decl. PA = 74 01
diff. rt. aſc. ∠APB = 9 45
Required the ∠BAP = 157 46

In the triangle APZ.
Given A's co-decl. PA = 74° 01′
the co-lat. PZ = 38 28
the ſupl. of BAP or ∠PAZ = 22 14
Req. ∠APZ = 144° 10′ or = 23 00

Now (by 966) the ſtar Aldebaran comes to the meridian at 11 h. 32 m. in the evening; which leſſened by 1 h. 32 m. (= 23° 00′) gives 9 h. 40 m. for the time in the evening when thoſe ſtars will be on the ſame azimuth.

1025. PROBLEM XXXVII.

At what time in the evening will the ſtars Betelgeuſe aud Pollux have one common altitude above the horizon of London, on the 10th of December, 1753?

Betelgeuſe right aſcen. = 5 h. 42 m.; decl. = 7° 20′ N. Pollux right aſcen. = 7 h. 28 m.; decl. = 28° 36′ N.

Their difference of right aſcenſion is 1 h. 46 m. = 26° 30′.

Construction. On a primitive circle, where any point P repreſents the pole of the equinoctial, put the ſtars Pollux at B, and Betelgeuſe at A, by their decl. and diff. of right aſcenſions; thro' A, B, deſcribe a great circle; thro' C, the middle of AB, deſcribe a great circle at right angles to AB, and cutting PA in D; then a ſmall circle deſcribed about P, at the diſtance of 38° 28′, the co-lat., will cut the circle CD in Z the zenith.

For the ſtars A and B having a common altitude, are equally diſtant from Z.

Computation. In the triangle APB.

Given A's co-decl. PA = 82° 40′ } Required the ∠BAP = 46° 1
B's co-decl. PB = 61 24 } AB = 32 4
diff. rt. aſc. ∠APB = 26 30 } Its half AC = 16 2

In the triangle ACD.

Given the ∠C = 90° 00′ } Required the ∠D = 46° 0
∠A = 46 18 } AD = 23 0
AC = 16 24 } Theref. PA − AD = PD = 59 3

In the triangle PDZ.

Given the co-lat. PZ = 38° 28′ } Required ∠ZPD = 66° 0
PD = 59 36 } Or it is = 58 3
∠PDZ = 46 05 }

Now (by 966) the ſtar comes to the meridian at 12 h. 32 m. in tl morning; from which take 3 h. 54 m. (= 58° 30′, as the ſtars are to tl eaſt of the meridian) and it leaves 8 h. 38 m. in the evening for the tin when thoſe ſtars have the ſame altitude.

1026. PROBLEM XXXVIII.

Wanting to know the latitude and longitude of a comet C, *its diſtance fro two known ſtars* A *and* B *were obſerved, and are as follows;*

A's *lat.* = 49° 12′ *N. Lon.* = 16° 39′ ♓; *diſtance from* C = 45° 05
B's *lat.* = 30 05 *N. Lon.* = 2 48 ♊; *diſtance from* C = 45 57

Hence the place of the comet C *is required?*

Construction. On the plane of the ſolſtitial colure, where E is tl pole of the ecliptic, put the ſtars A and B by their latitudes and long tudes, and deſcribe a great circle thro' A and B; then ſmall circles d ſcribed about A and B as poles, at the reſpective diſtances of the come their interſection C will give its place; deſcribe great circles thro' A, C B, C; E, C; and EC will be the co-lat., and from ∠AEC will be obtain the longitude.

Computation. In the △AEB.

Given A's co-lat. AE = 40° 48′
B's co-lat. BE = 59 55
diff. longit. ∠AEB = 76 09

Required AB = 59 01
and ∠EAB = 78 31

In the triangle ABC.

Given the diſtance AB = 59° 0
diſtance AC = 49 0
diſtance BC = 45 5

Required the ∠BAC = 56 2
Then ∠EAB + ∠BAC = ∠EAC = 134° 5

In the triangle CEA.

Given A's co-lat. AE = 40° 48′ } Required the co-lat. EC = 81° 3
diſtance AC = 49 05 } diff. lon. AEC = 32 4
and the ∠EAC = 134 58 } Hence lat. is 8° 27′ N. lon. 19° 22′ in ♈

1027. PROBLEM XXXIX.

The diſtance of the ſtar C *being obſerved from two ſtars,* A, B, *who latitude and diſtance are known; thence to find the lat. and long. of* C.

A's lat. = 5° 30′; diſt. from C = 39° 40′: B's lat. = 9° 57′; diſt. fro C = 10° 7½′: And the diſtance of AB is 44° 43′.

Con

Construction. On a circle of longitude, where E is the pole of the ecliptic, put the ſtar B by its lat.; about the points B and E deſcribe circles at the diſtances of A from thoſe points, their interſection gives the place of A; alſo circles deſcribed from A and B, at the diſtances of C reſpectively from them, their interſection is the place of C: Then deſcribe the great circles EA, EC; AC, AB; BC; and EC, will be the co-lat., and ∠BEC the longitude from B.

Computation. In the △AEB.
Given A's co-lat. AE = 84° 30′
B's co-lat. BE = 80 03
the diſtance AB = 44 43
Required the ∠ABE = 92 14

In the triangle ABC.
Given the diſtance AB = 44° 43′
diſtance AC = 39 40
diſtance BC = 10 07½
Required the ∠ABC = 55 22

In the triangle BEC.
Given B's co-lat. BE = 80° 03′
the diſtance BC = 10 07½
(∠ABE − ∠ABC =) ∠CBE = 36 52
Required C's co-lat. CE = 72° 01′
C's lon. fr. B, ∠BEC = 6 22

1028. PROBLEM XL.

From the altitudes of two known fixed ſtars, and the altitude of a planet when in the ſame azimuth with one of theſe ſtars; to find the place of the planet.

Exam. Obſerved the Moon and Cor. Leonis in the ſame azimuth, when he Moon's zenith diſtance was 36° 37′.
Cor. Leonis's zenith diſt. = 45° 00′; decl. 13° 09′ N.; rt. aſ. 9h 53m.
Cor. Hydra's zenith diſt. = 49 16; decl. 7 37 S.; rt. aſ. 9 16.

Construction. On the plane of the equinoctial, whoſe pole is P, draw the colures, and in the ſolſtitial, take E for the pole of the ecliptic; put the given ſtars at B and A by their declinations and right aſcenſions: About B and A as poles, with their reſpective zenith diſtances, deſcribe ircles cutting in Z the zenith; thro' Z and B deſcribe an azimuth circle, nd making Z☽ equal to the ☽'s zenith diſtance, gives her place: Then deſcribe the great circles ZB, ZA, Z☽; E☽; and the arc E☽ will be the o-latitude, and ∠PE☽ the longitude from ♋.

Computation. In the △ABP.
Given A's co-decl. PA = 97° 37′
B's co-decl. PB = 76 51
diff. rt. aſ. ∠BPA = 9 15
Required the ∠ABP = 155 38
the ſide AB = 22 43

In the triangle AZB.
Given A's zen. diſt. ZA = 49° 16′
B's zen. diſt. ZB = 45 00
the ſide AB = 22 43
Required the ∠ABZ = 89 56
Then ∠ABP − ∠ABZ = ∠ZBP = 65° 42′.

In the triangle B☽P.
Given B's co-decl. BP = 76° 51′
(BZ − Z☽ =) ſide B☽ = 8 23
∠PB☽ = 65 42
Requ. ☽'s co-decl. P☽ = 73 32
☽'s rt. aſ. fr. B, ∠BP☽ = 7 57
Then 90° + ∠♎PB + ∠BP☽ = ∠EP☽ = 129° 22′.

In the triangle P☽E.
Given obl. of eclip. PE = 23° 29′
☽'s co-decl. P☽ = 73 32
☽'s co-rt. aſ. ∠EP☽ = 129 22
Requir. ☽'s co-lat. ☽E = 89 00
☽'s lon. fr. ♋, ∠PE☽ = 47 52

SECTION VIII.

1029. ### Of the Uſe of the Globes.

By the Globes here are meant two ſpherical bodies, whoſe conve ſurfaces are ſuppoſed to give a true repreſentation of the earth and heavens, as viſible by obſervation, and are called the Terreſtrial and Celeſtial globes.

The Terrestrial globe has delineated on its convexity, the who ſurface of the *earth* and *ſea* in their relative ſize, form and ſituation.

The Celestial globe has drawn on its ſurface, the images of th ſeveral conſtellations and ſtars: The relative magnitude and poſitio which the ſtars are obſerved to have in the heavens, being preſerved o this globe.

To the globes are fitted certain appurtenances, whereby a great variety of uſeful problems are neatly ſolved.

The Brazen meridian is that ring or hoop in which the glob hangs on its axis; which is repreſented by two wires paſſing thro' i poles. This circle is divided into four quarters of 90° each; in one ſemicircle the diviſions begin at each pole, and end at 90°, where the meet: In the other ſemicircle, the diviſions begin at the middle, and proceed thence towards each pole, where they end at 90 degrees. Th graduated ſide of this brazen circle ſerves as a meridian for any point o the ſurface of the earth, the globe being turned about till that poin comes under the circle.

The Hour circle is a ſmall circle of braſs which is divided into 2 hours, the quarters and half quarters; It is fixed on the brazen meridia equally diſtant from the north end of the axis, to which an index is fitte that points out the diviſions of the hour circle as the globe is turned abou

The Horizon is repreſented by the upper ſurface of the wooden circular frame encompaſſing the globe about its middle. On this wooden fram is a kind of perpetual calendar, contained in ſeveral concentric circles The inner one is divided into 4 quarters of 90 degrees each; the nex circle is divided into the 12 months, with the days in each, according t the new ſtile; the next contains the 12 equal ſigns of the zodiac, eac being divided into 30 degrees; the next is the 12 months and days according to the old ſtile; and there is another circle, containing the 32 wind with their halves and quarters. Altho' theſe circles are on all horizon yet their diſpoſition by the workmen are not always the ſame.

The Quadrant of altitude is a thin ſlip of braſs, one edge o which is graduated into 90 degrees and their quarters, equal to thoſe of th meridian: To one end of this is fixed a braſs nut and ſcrew, whereby it put on and faſtened to the meridian; which, if in the zenith or pole of th horizon, then the graduated edge repreſents a vertical circle paſſing thr any point.

Beſide theſe, there are ſeveral circles deſcribed on the ſurfaces of bot globes, ſuch as the equinoctial, ecliptic, circles of longitude and right aſcenſion, the tropics, polar circles, parallels of lat. and decl., on the celeſti globe; and on the terreſtrial, the equator, ecliptic, tropics, polar circle parallels of latitude, hour circles, or meridians to every 15 degrees, and th ſpiral rhumbs flowing from ſeveral centres, called Flies.

103

030.

PROBLEM I.

To find the latitude and longitude of any place on the terreſtrial globe.

1ſt. Bring the given place under that ſide of the graduated brazen meidian where the degrees begin at the equator, by turning the globe about.
2d. Then the degree of the meridian over it, ſhews the latitude.
3d. And the degree of the equator under the merid., ſhews the longit.

On ſome globes, the longitude is reckoned on the equator, from the eridian where it begins, only eaſtward until it ends at 360°: On ſuch obes, when the longitude of a place exceeds 180°, take it from 360°, d call the remainder the longitude weſtward.

31.

PROBLEM II.

To find any place on the globe whoſe latitude and longitude are given.

1ſt. Bring the given longitude, found on the equator, to the meridian.
2d. Then under the given latitude, found on the meridian, is the place ught.

32.

PROBLEM III.

To find the diſtance and bearing of any two given places on the globe.

1ſt. Lay the graduated edge of the quadrant of altitude over both places, e beginning, or 0 deg. being on one of them, and the degrees between em ſhews their diſtance; theſe degrees multiplied by 60 gives ſea miles, d by 70 gives the diſtance in land miles nearly.
2d. Obſerve while the quadrant lies in this poſition, what rhumb of e neareſt fly runs moſtly parallel to the edge of the quadrant, and that umb ſhews the bearing ſought nearly.

33.

PROBLEM IV.

To find the ſun's place and declination on any day.

1ſt. Seek the given day in the circle of months on the horizon, and ht againſt it, in the circle of ſigns, is the ſun's place.
Thus it will be found that the ſun enters
e ſpring ſigns, Aries, March 20. Taurus, April 20. Gemini, May 21.
e ſummer ſigns, Cancer, June 21. Leo July 23. Virgo, Auguſt 23.
tumnal ſigns, Libra, Sept. 22. Scorpio, Oct. 23. Sagittar. Nov. 22.
e winter ſigns, Capric. Dec. 21. Aquarius, Jan. 20. Piſces, Feb. 18.
2d. Seek the ſun's place in the ecliptic on the globe, bring that place the meridian, and the diviſion it ſtands under is the ſun's declination the given day.

On the globes, the ecliptic is readily diſtinguiſhed from the equator, t only by the different colours wherewith they are ſtained, but alſo the ecliptic's approaching towards the poles, after its interſection with equator. The marks of the ſigns are alſo put along the ecliptic, at the beginning of every ſucceſſive 30 degrees.

1034. PROBLEM V.

To rectify the globe for the latitude, zenith, and noon.

1ſt. Set the globe upon an horizontal plane, with its parts anſwerin to thoſe of the world; move the meridian in its notches, by raiſing depreſſing the pole, until the degrees of latitude cut the horizon; the is the globe rectified for the latitude.

2d. Reckon the latitude from the equator towards the elevated pol there ſcrew the bevil edge of the nut belonging to the quadrant of alt tude, and the rectification is made for the zenith.

3d. Bring the ſun's place (found by the laſt problem) to the meridia ſet the index to the XII at noon, or upper XII, and the globe is rect fied for the ſun's ſouthing, or noon.

1035. PROBLEM VI.

To find where the ſun is vertical at any given time.

1ſt. Bring the ſun's place, found for the given day (1033), to the m ridian, note the degree over it, and ſet the index to the given hour.

2d. Turn the globe till the index comes to 12 at noon, then the pla under the ſaid noted degree has the ſun in the zenith at that time.

3d. All the places that paſs under that degree, by turning the glo round, will have the ſun vertical to them on that day.

1036. PROBLEM VII.

To find what days the ſun will be vertical at any given place in the tor zone.

1ſt. Note the latitude of the given place on the meridian.

2d. Turn the globe, and note what points of the ecliptic paſs und the latitude noted on the meridian.

3d. Seek thoſe points of the ecliptic in the circle of ſigns on the h rizon, and right againſt them in the circle of months ſtand the da required.

In this manner it will be found, that the ſun will be vertical to the land of St. Helena on the 6th of November, and on the 4th of Februa And at Barbadoes on the 24th of April, and the 18th of Auguſt.

1037. PROBLEM VIII.

At any given hour in a given place, to find what hour it is in any ot place?

1ſt. Bring the place where the time is given to the meridian, and the index to the given hour.

2d. Bring the other given place to the meridian, and the index ſhe the hour correſponding to the given time.

038. PROBLEM IX.

At any given time, to find all thoſe places of the earth where the ſun is hen riſing or ſetting, where mid-day or midnight.

Find the place where the ſun is vertical at the given time (1035); ectify the globe for the latitude of that place, and bring it to the me-idian.

Then all thoſe places, that are in the weſt half of the horizon, have he ſun riſing; and thoſe in the eaſtern half have it ſetting.

Thoſe under the meridian above the horizon have the ſun culminating, r noon; and thoſe under the meridian below the horizon have midnight:

Thoſe above the horizon have day; thoſe below it have night.

039. PROBLEM X.

To find the angle of poſition of two places; or, the angle made by the me-dian of one place, and a great circle paſſing thro' both places.

Rectify for the latitude of one of the given places, and bring it to the eridian; there fix the quadrant of altitude, and ſet its graduated edge the other place: Then will that edge of the quadrant cut the horizon the degree of poſition ſought.

Thus, the angle of poſition at the Land's end to Barbadoes is ſouth 1½° weſterly: But the angle of poſition at Barbadoes to the Land's end north 37½ degrees eaſterly.

Hence neither of theſe poſitions can be the true bearing; for the rhumb ſſing thro' both places, will be oppoſite one way to what it is the other.

040. PROBLEM XI.

The latitude of any place not within the polar circle being given, to find e time of ſun-riſing and ſetting, and the length of the day and night.

Rectify for the latitude and the noon; bring the ſun's place to the ſtern ſide of the horizon, and the index ſhews the time of riſing: The n's place brought to the weſtern ſide of the horizon, the index gives e ſetting.

Or, The time of riſing taken from 12 hours gives the time of ſetting.

The time of ſetting being doubled gives the length of the day.

And the time of riſing being doubled gives the length of the night.

Thus, at London, on April 15th, the day is 13½ hours; the night ½ hours.

41. PROBLEM XII.

To find the length of the longeſt and ſhorteſt days in any given place.

Rectify for the latitude; bring the ſolſtitial point of that hemiſphere the eaſtern part of the horizon, ſet the index to 12 at noon; turn the obe till the ſolſtitial point comes to the weſtern ſide of the horizon, e hours paſt over by the index give the length of the longeſt day, or ght; and its complement to 24 hours gives the length of the ſhorteſt ght, or day.

1042. PROBLEM XIII.

A place being given in either frigid or frozen zone, to find the time wh the ſun begins to appear at, or depart from, that place: Alſo how many ſu ceſſive days he is preſent to, or abſent from, that place.

Rectify for the latitude, turn the globe, and obſerve what degrees the firſt and ſecond quadrants of the ecliptic are cut by the north poi of the horizon, the latitude being ſuppoſed north.

Find thoſe degrees in the circle of ſigns on the horizon, and th correſponding days of the month, and all the time between thoſe days t ſun will not ſet in that place.

Again. Obſerve what degree in the third and fourth quadrants of t ecliptic will be cut by the ſouth point of the horizon, and the days a ſwering: Then the ſun will be quite abſent from the given place duri the intermediate days; that day in the 3d quadrant, ſhews when he b gins to diſappear; and that in the 4th quadrant, ſhews when he begi to ſhine in the place propoſed.

Thus, at the North cape, in lat. 71°, the ſun never ſets from May to July 28, which is 74 days; and never riſes from November 16 January 24, which is 69 days.

1043. PROBLEM XIV.

To find the antæci, periæci, and antipodes of any place.

Bring the given place to the meridian, tell as many degrees of latitu on the contrary ſide of the equator, and it gives the place of the antæc that is, of thoſe who have oppoſite ſeaſons of the year, but the ſar times of the day.

The given place being under the meridian, ſet the index to 12 noon, turn the globe till the index points to 12 at night, and the poi under the meridian in the given latitude is the place of the periæci; th is, of thoſe who have the ſame ſeaſons of the year, but oppoſite tim of the day.

The globe remaining in this poſition, ſeek on the contrary ſide t equator for the degrees of latitude given, and the point under the me dian thus found will be the antipodes to the given place; that is, of ſu whoſe ſeaſons of the year and times of the day are directly oppoſite thoſe of the given place.

1044. PROBLEM XV.

To find the beginning and end of the twilight in any place.

Rectify the globe for the latitude, zenith, and noon. (103

Seek the point of the ecliptic oppoſite to the ſun's place, turn t globe and quadrant of altitude, till the ſaid oppoſite point of the eclipt ſtands againſt 18 degrees on the quadrant of altitude; then will the ind ſhew the beginning or end of the twilight: That is, the beginning the morning, when thoſe points meet in the weſtern hemiſphere; or t end in the evening, when the ſaid points meet in the eaſtern hemiſpher

1045. PROBLEM XVI.

The latitude of a place and day of the month being given; to find the ſun's declination, meridian altitude, right aſcenſion, amplitude, oblique aſcenſion, aſcenſional difference; and thence the time of riſing, ſetting, length of the day and night.

Rectify for the latitude and noon. Then

The degree of the meridian over the ſun's place is the declination.

The meridian altitude is ſhewn by the degrees the ſun is above the hoizon; and is equal to the ſum or diff. of the co-lat and declin.

The ſun's right aſcen. is that degree of the equator under the meridian.

Bring the ſun's place to the eaſtern part of the horizon. Then

The amplitude is that degree of the horizon oppoſite the ſun.

The oblique aſcenſion is that degree of the equator cut by the horizon.

The aſcen. diff. is the diff. between the right and oblique aſcenſions.

The aſcen. diff. converted into time, will give the time the ſun riſes efore or after the hour of ſix, according as his amplitude is to the orthward or ſouthward of the eaſt point of the horizon.

046. PROBLEM XVII.

Given the latitude of the place and day of the month; to find the ſun's ltitude and azimuth, either when he is due eaſt or weſt, at 6 o'clock, or at ny other hour while he is above the horizon.

Rectify the globe for the latitude, zenith, and noon.

Set the quadrant of altitude to the eaſt point of the horizon, turn the lobe till the ſun's place comes to the quadrant's edge, and it ſhews the ltitude, his azimuth being now 90°, and the index ſhews the hour.

Turn the globe till the index points at 6, there ſtay it, and move the uadrant till its edge cuts the ſun's place; then the degrees at the ſun hews its altitude, and the degrees cut by the quadrant in the horizon hews the azimuth, reckoning from the north.

In like manner, the globe being turned till the index is againſt any ther hour, ſuppoſe 10 in the forenoon. Then

The graduated edge of the quadrant of altitude being turned to cut he ſun's place, will give both the altitude and azimuth at that time.

047. PROBLEM XVIII.

Given the latitude, day of the month, and ſun's altitude; to find the aziuth and hour of the day.

Rectify the globe for the latitude, zenith, and noon.

Turn the globe and quadrant until the ſun's place coincide with the raduated edge of the quadrant.

Then will that edge of the quadrant cut in the horizon the degrees of zimuth, reckoned from the north; and the index will ſhew the hour f the day.

1048. PROBLEM XIX.

To repreſent the appearance of the heavens at any time in a given place.

Rectify the celeſtial globe for the latitude, zenith, and noon, an turn the globe till the index points at the given hour. Then

Thoſe ſtars in the eaſtern half of the horizon are riſing; thoſe in th weſtern are ſetting; and thoſe in the meridian are culminating.

The quadrant being ſet to any given ſtar will ſhew its altitude, and a the ſame time its azimuth, reckoned in the horizon.

Now by turning the globe round, it will readily appear what ſtar never ſet in that place, and thoſe which never riſe; thoſe of perpetua apparition never go below the horizon, and thoſe of perpetual abſenc never come above it.

1049. PROBLEM XX.

To find the latitude and longitude of any ſtar.

Put the centre of the quadrant of altitude on the pole of the ecliptic and its graduated edge on the given ſtar. Then

The latitude is ſhewn by the degrees between the ecliptic and ſtar.

The longitude is the degrees cut on the ecliptic by the quadrant.

1050. PROBLEM XXI.

To find the declination and right aſcenſion of a ſtar.

Bring the ſtar to the meridian, the degree over it is the declination and the degree of the equator under the meridian is the right aſcenſion.

1051. PROBLEM XXII.

On any day, and in any given place; to find when a propoſed ſtar riſe ſets, or culminates.

Rectify the globe for the latitude and noon.

Bring the ſtar to the eaſtern ſide of the horizon, and the index ſhew the time of its riſing.

Turn the globe till the ſtar comes to the meridian, and the inde ſhews the time of its culminating; and in like manner when it ſets, th time will be ſhewn by the index.

Its meridian altitude, oblique aſcenſion, and aſcenſional difference, ar found in the ſame manner as for the ſun at art. 1045.

Articles 1052, 1053, 1054, 1055, 1056.

ASTRONOMICAL TABLES
OF THE
Declinations and Right Aſcenſions
OF THE
Sun and Fixed Stars:

Calculated for the year 1753,
And ſerving for the next twelve years.

ALSO,

A TABLE to reduce the Sun's declination from the meridian of London to that of any other place.

And a uſeful TABLE of Refractions.

1052. A TABLE of the Sun's Declination

For the years 1753, 1757, 1761; each being the firſt after Leap-yea

Days	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Days
	Decl. S.	Decl. S.	Decl. S.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. S.	Decl. S.	Decl. S.	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
1	22 59	16 58	7 24	4 43	15 12	22 07	23 07	17 58	8 10	3 20	14 36	21 55	1
2	22 53	16 41	7 01	5 06	15 30	22 15	23 03	17 43	7 49	3 44	14 55	22 04	2
3	22 48	16 23	6 38	5 29	15 48	22 23	22 58	17 27	7 27	4 07	15 13	22 12	3
4	22 41	16 05	6 15	5 52	16 05	22 30	22 53	17 11	7 04	4 30	15 32	22 20	4
5	22 35	15 46	5 52	6 14	16 22	22 36	22 48	16 55	6 42	4 53	15 50	22 28	5
6	22 27	15 28	5 29	6 37	16 39	22 43	22 42	16 39	6 20	5 16	16 08	22 35	6
7	22 20	15 09	5 05	6 59	16 56	22 49	22 35	16 22	5 57	5 39	16 26	22 42	7
8	22 12	14 50	4 42	7 22	17 12	22 54	22 28	16 05	5 34	6 02	16 44	22 48	8
9	22 03	14 31	4 19	7 44	17 28	22 59	22 21	15 48	5 12	6 25	17 01	22 54	9
10	21 54	14 11	3 55	8 06	17 44	23 04	22 14	15 30	4 49	6 48	17 18	22 59	10
11	21 45	13 52	3 32	8 28	17 59	23 08	22 06	15 12	4 26	7 11	17 34	23 04	11
12	21 35	13 32	3 08	8 50	18 14	23 12	21 58	14 54	4 03	7 34	17 51	23 09	12
13	21 24	13 11	2 44	9 12	18 29	23 15	21 49	14 36	3 40	7 56	18 07	23 13	13
14	21 14	12 51	2 21	9 34	18 44	23 19	21 40	14 17	3 17	8 18	18 23	23 16	14
15	21 03	12 30	1 57	9 55	18 58	23 21	21 31	13 59	2 54	8 41	18 38	23 20	15
16	20 51	12 10	1 33	10 16	19 12	23 23	21 21	13 40	2 31	9 03	18 53	23 22	16
17	20 39	11 49	1 10	10 37	19 25	23 25	21 11	13 21	2 07	9 25	19 08	23 24	17
18	20 27	11 27	0 46	10 58	19 39	23 27	21 00	13 01	1 44	9 47	19 22	23 26	18
19	2 14	11 06	0 22	11 19	19 52	23 28	20 50	12 42	1 21	10 09	19 36	23 27	19
20	20 01	10 45	N. 01	11 40	20 04	23 29	20 38	12 22	0 57	10 30	19 50	23 28	20
21	19 48	10 23	0 25	12 00	20 16	23 29	20 27	12 02	0 34	10 52	20 03	23 29	21
22	19 34	10 01	0 49	12 20	20 28	23 28	20 15	11 42	0 11	11 13	20 16	23 28	22
23	19 20	9 39	1 12	12 40	20 40	23 27	20 03	11 21	S. 13	11 34	20 28	23 27	23
24	19 06	9 17	1 36	13 00	20 51	23 26	19 50	11 01	0 36	11 55	20 41	23 26	24
25	18 51	8 55	1 59	13 20	21 02	23 25	19 37	10 40	1 00	12 16	20 52	23 25	25
26	18 36	8 32	2 23	13 39	21 12	23 23	19 24	10 19	1 23	12 36	21 04	23 23	26
27	18 20	8 10	2 46	13 58	21 22	23 21	19 10	9 58	1 47	12 57	21 15	23 20	27
28	18 04	7 47	3 10	14 17	21 32	23 18	18 57	9 37	2 10	13 17	21 25	23 17	28
29	17 48		3 33	14 36	21 42	23 15	18 43	9 15	2 34	13 37	21 36	23 14	29
30	17 32		3 56	14 54	21 51	23 11	18 28	8 54	2 57	13 57	21 45	23 10	30
31	17 15		4 20		21 59		18 13	8 32		14 17		23 05	31
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
Days	S. Decl.	S. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	S. Decl.	S. Decl.	S. Decl.	S. Decl	Days
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	

A TABL

1052. A TABLE of the Sun's Declination

or the years 1754, 1756, 1762; each being the ſecond after Leap-year.

Days	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Days
	Decl. S.	Decl. S.	Decl. S.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. S.	Decl. S.	Decl. S.	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
1	23 00	17 02	7 30	4 37	15 08	22 05	23 08	18 02	8 16	3 15	14 31	21 53	1
2	22 55	16 45	7 07	5 00	15 26	22 13	23 04	17 47	7 54	3 38	14 50	22 02	2
3	22 49	16 27	6 44	5 23	15 43	22 21	22 59	17 31	7 32	4 01	15 09	22 10	3
4	22 43	16 09	6 21	5 46	16 01	22 28	22 54	17 15	7 10	4 24	15 28	22 18	4
5	22 36	15 51	5 58	6 09	16 18	22 35	22 49	16 59	6 47	4 48	15 46	22 26	5
6	22 29	15 32	5 34	6 31	16 35	22 41	22 43	16 43	6 25	5 11	16 04	22 33	6
7	22 22	15 14	5 11	6 54	16 52	22 47	22 37	16 26	6 03	5 34	16 22	22 40	7
8	22 14	14 55	4 48	7 16	17 08	22 53	22 30	16 09	5 40	5 57	16 40	22 47	8
9	22 05	14 36	4 24	7 39	17 24	22 58	22 23	15 52	5 17	6 20	16 57	22 53	9
10	21 56	14 16	4 01	8 01	17 40	23 01	22 16	15 34	4 55	6 43	17 14	22 58	10
11	21 47	13 56	3 37	8 23	17 56	23 07	22 08	15 17	4 32	7 05	17 31	23 03	11
12	21 37	13 36	3 14	8 45	18 11	23 11	22 00	14 59	4 09	7 28	17 47	23 08	12
13	21 27	13 16	2 50	9 07	18 26	23 15	21 51	14 40	3 46	7 51	18 03	23 12	13
14	21 16	12 56	2 27	9 28	18 40	23 18	21 42	14 22	3 23	8 13	18 19	23 16	14
15	21 05	12 35	2 03	9 50	18 55	23 21	21 33	14 03	2 59	8 35	18 34	23 19	15
16	20 54	12 15	1 39	10 11	19 09	23 23	21 23	13 44	2 36	8 58	18 49	23 22	16
17	20 42	11 54	1 15	10 32	19 22	23 25	21 13	13 25	2 13	9 20	19 04	23 24	17
18	20 30	11 33	0 52	10 53	19 36	23 26	21 03	13 06	1 50	9 42	19 19	23 26	18
19	20 18	11 11	0 28	11 14	19 48	23 27	20 52	12 46	1 26	10 03	19 33	23 27	19
20	20 05	10 50	0 04	11 35	20 01	23 28	20 41	12 27	1 03	10 25	19 46	23 28	20
21	19 51	10 28	N. 19	11 55	20 13	23 29	20 30	12 07	0 40	10 47	20 00	23 29	21
22	19 38	10 06	0 43	12 15	20 25	23 29	20 18	11 47	0 16	11 08	20 13	23 29	22
23	19 24	9 44	1 07	12 35	20 37	23 28	20 06	11 26	S. 07	11 29	20 25	23 28	23
24	19 09	9 22	1 30	12 55	20 48	23 27	19 53	11 06	0 31	11 50	20 38	23 27	24
25	18 54	9 00	1 54	13 15	20 59	23 25	19 40	10 45	0 54	12 11	20 50	23 25	25
26	18 39	8 37	2 17	13 34	21 10	23 24	19 27	10 24	1 18	12 32	21 01	23 23	26
27	18 24	8 15	2 41	13 53	21 20	23 21	19 14	10 03	1 41	12 52	21 12	23 21	27
28	18 08	7 52	3 04	14 12	21 30	23 19	19 00	9 42	2 04	13 12	21 23	23 18	28
29	17 52		3 27	14 31	21 39	23 16	18 46	9 21	2 28	13 32	21 33	23 15	29
30	17 36		3 51	14 50	21 48	23 12	18 32	8 59	2 51	13 52	21 43	23 11	30
31	17 19		4 14		21 57		18 17	8 38		14 12		23 06	31
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
	S. Decl.	S. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	S. Decl.	S. Decl.	S. Decl.	S. Decl.	Days
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	

1052. A TABLE of the Sun's Declination

For the years 1755, 1759, 1763; each being the third after Leap-yea

Days	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Days
	Decl. S.	Decl. S.	Decl. S.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. S.	Decl. S.	Decl. S.	
	° '	° '	° '	° '	° '	° '	° '	° '	° '	° '	° '	° '	
1	23 02	17 07	7 36	4 31	15 03	22 03	23 09	18 06	8 22	3 08	14 26	21 50	1
2	22 56	16 49	7 13	4 54	15 21	22 11	23 05	17 51	8 00	3 32	14 45	21 59	2
3	22 51	16 31	6 50	5 17	15 39	22 19	23 01	17 35	7 38	3 55	15 04	22 08	3
4	22 45	16 14	6 27	5 40	15 56	22 26	22 56	17 20	7 16	4 18	15 23	22 16	4
5	22 38	15 56	6 04	6 03	16 13	22 33	22 51	17 04	6 54	4 41	15 41	22 24	5
6	22 31	15 37	5 41	6 25	16 30	22 39	22 45	16 47	6 31	5 05	15 59	22 31	6
7	22 24	15 19	5 17	6 48	16 47	22 45	22 39	16 31	6 09	5 28	16 17	22 38	7
8	22 16	15 00	4 54	7 10	17 04	22 51	22 32	16 14	5 46	5 51	16 35	22 45	8
9	22 07	14 41	4 31	7 33	17 2	22 56	22 25	15 56	5 24	6 14	16 52	22 51	9
10	21 59	14 21	4 07	7 55	17 36	23 02	22 18	15 39	5 01	6 36	17 09	22 57	10
11	21 49	14 02	3 44	8 17	17 51	23 06	22 10	15 21	4 38	6 59	17 26	23 02	11
12	21 40	13 42	3 20	8 39	18 07	23 10	22 02	15 03	4 15	7 21	17 42	23 07	12
13	21 30	13 21	2 57	9 01	18 22	23 14	21 54	14 45	3 52	7 44	17 59	23 11	13
14	21 19	13 02	2 33	9 23	18 36	23 17	21 45	14 27	3 29	8 07	18 14	23 15	14
15	21 08	12 41	2 09	9 44	18 51	23 20	21 36	14 08	3 06	8 29	18 30	23 18	15
16	20 57	12 20	1 46	10 05	19 05	23 22	21 26	13 50	2 43	8 52	18 45	23 21	16
17	20 46	11 59	1 22	10 27	19 18	23 24	21 16	13 30	2 19	9 14	19 00	23 22	17
18	20 33	11 38	0 58	10 48	19 32	23 26	21 06	13 11	1 56	9 36	19 1	23 25	18
19	20 21	11 17	0 35	11 08	19 45	23 27	20 55	12 52	1 33	9 57	19 29	23 27	19
20	20 08	10 56	0 11	11 29	19 58	23 28	20 44	12 32	1 09	10 19	19 43	23 28	20
21	19 55	10 34	N. 13	11 50	20 1	23 29	20 33	12 12	0 46	10 41	19 56	23 29	21
22	19 42	10 12	0 36	12 10	20 22	23 29	20 21	11 52	0 23	11 02	20 09	23 29	22
23	19 27	9 51	1 00	12 30	20 34	23 28	20 09	11 32	S. 01	11 23	20 22	23 28	23
24	19 13	9 28	1 24	12 50	20 45	23 27	19 57	11 11	0 24	11 44	20 34	23 27	24
25	18 59	9 06	1 47	13 10	20 56	23 26	19 44	10 51	0 48	12 05	20 46	23 26	25
26	18 43	8 44	2 11	13 29	21 07	23 24	19 31	10 30	1 11	12 26	20 58	23 24	26
27	18 28	8 21	2 34	13 48	21 17	23 22	19 18	10 09	1 35	2 46	21 09	23 21	27
28	18 12	7 59	2 58	14 07	21 27	23 19	19 04	9 48	1 58	13 07	21 19	23 19	28
29	17 56		3 21	14 26	21 37	23 17	18 50	9 26	2 21	13 27	21 30	23 15	29
30	17 40		3 44	14 44	21 46	23 13	18 36	9 0	2 45	13 47	21 40	23 12	30
31	17 23		4 08		21 55		18 21	8 43		14 06		23 08	31
	° '	° '	° '	° '	° '	° '	° '	° '	° '	° '	° '	° '	
Days	S. Decl.	S. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	S. Decl.	S. Decl.	S. Decl.	S. Decl.	Days
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.	

A TABL

1052. A TABLE of the Sun's Declination

For the years 1756, 1760, 1764; each being Leap-year.

Days	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Days
	Decl. S.	Decl. S.	Decl. S.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. N.	Decl. S.	Decl. S.	Decl. S.	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
1	23 03	17 11	7 19	4 48	15 17	22 09	23 06	17 55	8 05	3 26	14 40	21 57	1
2	22 58	16 53	6 50	5 11	15 34	22 17	23 0[illegible]	17 39	7 43	3 49	14 59	22 06	2
3	22 52	16 36	6 33	5 34	15 52	22 24	22 57	17 23	7 21	4 13	15 18	22 14	3
4	22 46	16 18	6 10	5 57	16 09	22 31	22 52	17 07	6 59	4 36	15 37	22 22	4
5	22 40	16 00	5 46	6 20	16 26	22 38	22 46	16 51	6 37	4 59	15 55	22 30	5
6	22 33	15 42	5 23	6 42	16 43	22 44	22 40	16 3[illegible]	6 14	5 22	16 13	22 37	6
7	22 25	15 23	5 00	7 05	17 00	22 50	22 34	16 18	5 52	5 45	16 3[illegible]	22 43	7
8	22 18	15 05	4 36	7 27	17 16	22 55	22 2[illegible]	16 00	5 29	6 08	16 48	22 5	8
9	22 10	14 45	4 13	7 50	17 32	23 00	22 20	15 43	5 06	6 31	17 05	22 55	9
10	22 01	14 26	3 49	8 12	17 48	23 05	22 12	15 26	4 43	6 54	17 26	23 01	10
11	21 52	14 07	3 26	8 34	18 03	23 09	22 04	15 08	4 21	7 16	17 39	23 05	11
12	21 42	13 47	3 02	8 [illegible]6	18 18	23 1[illegible]	21 56	14 50	3 58	7 39	17 [illegible]5	23 10	12
13	21 32	13 27	2 39	9 17	18 33	23 16	21 47	14 31	3 35	8 0	18 11	23 14	13
14	21 22	13 06	2 15	9 39	18 47	23 19	21 38	14 13	3 11	8 24	18 26	23 17	14
15	21 11	12 46	1 51	10 00	19 01	23 2[illegible]	21 2[illegible]	13 54	2 48	8 46	18 41	23 20	15
16	20 50	12 25	1 28	10 22	19 1[illegible]	23 24	21 19	13 35	2 2[illegible]	9 08	18 57	23 23	16
17	20 48	12 05	1 04	10 43	19 29	23 26	21 08	13 16	2 02	9 30	19 11	23 25	17
18	20 36	11 43	0 40	11 03	19 42	23 27	20 [illegible]8	12 56	1 38	9 52	19 25	23 2[illegible]	18
19	20 24	11 22	0 17	11 24	19 5[illegible]	23 28	20 47	12 37	1 1[illegible]	10 14	19 39	23 28	19
20	20 11	11 01	N. 07	1[illegible] 4[illegible]	20 07	23 29	20 3[illegible]	12 17	0 52	10 36	19 53	23 29	20
21	19 58	10 39	0 31	12 05	20 19	23 29	20 24	11 57	0 28	10 57	20 06	23 29	21
22	19 45	10 18	0 54	12 25	20 31	23 28	20 12	11 37	0 05	11 18	20 19	23 28	22
23	19 31	9 56	1 18	12 45	20 43	23 27	20 00	11 16	S. 19	11 39	20 31	23 27	23
24	19 17	9 34	1 42	13 05	20 54	23 26	19 47	10 56	0 42	12 00	20 43	23 26	24
25	19 02	9 11	2 05	13 24	21 04	23 24	19 34	10 3[illegible]	1 05	12 21	20 55	23 24	25
26	18 47	8 49	2 29	13 44	21 15	23 22	19 21	10 14	1 29	12 41	21 06	23 22	26
27	18 32	8 27	2 52	14 03	21 25	23 20	19 07	9 [illegible]3	1 52	13 02	21 17	23 19	27
28	18 16	8 04	3 15	14 21	21 35	23 [illegible]7	18 [illegible]3	9 32	2 16	13 22	21 28	23 [illegible]6	28
29	18 00	7 41	3 39	14 40	21 44	23 14	18 39	9 10	2 39	13 42	21 38	23 13	29
30	17 44		4 02	14 58	21 53	23 10	18 25	8 49	3 03	14 02	21 48	23 09	30
31	17 28		4 25		22 01		18 10	8 27		14 21		23 4	31
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
Days	S. Decl.	S. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	N. Decl.	S. Decl.	S. Decl.	S. Decl.	S. Decl.	Days
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	

1053. A TABLE of the Sun's Right Aſcenſion.

Days	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Days
	Right Aſc. H.M.	Right Aſc. H.M.	Right Aſc. H.M.	Right Aſc. H.M.	Right Aſc. H.M.	Right Aſc. H.M.	Right Aſc. H.M.	Right Aſc. H.M.	Right Aſc. H.M.	Right Aſc H.M.	Right Aſc. H.M.	Right Aſc. H.M.	
1	18 48	21 01	22 49	0 43	2 34	4 37	6 41	8 46	10 42	12 30	14 26	16 30	1
2	18 53	21 05	22 53	0 47	2 38	4 41	6 45	8 50	10 45	12 34	14 30	16 35	2
3	18 57	21 09	22 57	0 50	2 42	4 45	6 49	8 53	10 49	12 37	14 34	16 39	3
4	19 02	21 13	23 01	0 54	2 46	4 49	6 53	8 57	10 53	12 41	14 38	16 43	4
5	19 06	21 17	23 04	0 57	2 49	4 53	6 57	9 01	10 56	12 45	14 42	16 48	5
6	19 10	21 21	23 08	1 01	2 53	4 57	7 02	9 05	11 00	12 48	14 46	16 52	6
7	19 15	21 25	23 12	1 05	2 57	5 01	7 06	9 09	11 04	12 52	15 50	16 57	7
8	19 19	21 29	23 15	1 08	3 01	5 05	7 10	9 13	11 07	12 56	14 54	17 01	8
9	19 23	21 33	23 19	1 12	3 05	5 10	7 14	9 17	11 11	12 59	14 58	17 05	9
10	19 28	21 37	23 23	1 16	3 09	5 14	7 18	9 20	11 14	13 03	15 02	17 10	10
11	19 32	21 41	23 26	1 19	3 13	5 18	7 22	9 24	11 18	13 07	15 06	17 14	11
12	19 37	21 44	23 30	1 23	3 17	5 22	7 26	9 28	11 22	13 10	15 10	17 19	12
13	19 41	21 48	23 34	1 27	3 20	5 26	7 30	9 32	11 25	13 14	15 15	17 23	13
14	19 45	21 52	23 38	1 30	3 24	5 30	7 34	9 35	11 29	13 18	15 19	17 27	14
15	19 49	21 56	23 41	1 34	3 28	5 34	7 38	9 39	11 32	13 21	15 23	17 32	15
16	19 54	22 00	23 45	1 38	3 32	5 39	7 42	9 43	11 36	13 25	15 27	17 36	16
17	19 58	22 04	23 48	1 41	3 36	5 43	7 46	9 47	11 40	13 29	15 31	17 41	17
18	20 00	22 08	23 52	1 45	3 40	5 47	7 50	9 50	11 43	13 33	15 35	17 45	18
19	20 07	22 12	23 56	1 49	3 44	5 51	7 54	9 54	11 47	13 36	15 39	17 50	19
20	20 11	22 15	23 59	1 53	3 48	5 55	7 58	9 58	11 50	13 40	15 44	17 54	20
21	20 15	22 19	0 03	1 56	3 52	5 59	8 02	10 02	11 54	13 44	15 48	17 58	21
22	20 19	22 23	0 07	2 00	3 56	6 04	8 06	10 05	11 58	13 48	15 52	18 03	22
23	20 23	22 27	0 10	2 04	4 00	6 08	8 10	10 09	12 01	13 52	15 56	18 07	23
24	20 28	22 31	0 14	2 08	4 04	6 12	8 14	10 13	12 05	13 55	16 00	18 12	24
25	20 32	22 34	0 18	2 11	4 08	6 16	8 18	10 16	12 08	13 59	16 05	18 16	25
26	20 36	22 38	0 21	2 15	4 12	6 20	8 22	10 20	12 12	14 03	16 09	18 21	26
27	20 40	22 42	0 25	2 19	4 16	6 24	8 26	10 24	12 16	14 07	16 13	18 25	27
28	20 44	22 46	0 28	2 23	4 20	6 29	8 30	10 27	12 19	14 11	16 17	18 30	28
29	20 48		0 32	2 26	4 24	6 33	8 34	10 31	12 23	14 15	16 22	18 34	29
30	20 52		0 36	2 30	4 29	6 37	8 38	10 35	12 26	14 19	16 26	18 38	30
31	20 56		0 39		4 33		8 42	10 38		14 22		18 43	31
Days	H M. Right Aſc.	H.M. Right Aſc.	H.M. Right Aſc.	H.M. Right Aſc.	H.M. Right Aſc.	H.M. Right Aſc.	H.M. Right Aſc.	H.M. Right Aſc.	H.M. Right Aſc.	H.M. Right Aſc.	H.M. Right Aſc.	H.M. Right Aſc.	Days
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	

1054

1054. *A* Table *of the Right Aſcenſion and Declination of ſome of the principal Fixed Stars; as in the year* 1752.

	Conſtellation	Place in the Conſtellat.	Stars names	Mark	Magnit.	Rt. Aſc.		Declinat.	
						H.	M.	°	′
Constellations in the Zodiac.	Aries	Bright ſtar of Aries		α	3	1	53	22	17N.
	Taurus	The Bull's eye	Aldebaran	α	1	4	22	15	59N.
	Gemini	Southern twin	Pollux	β	2	7	28	28	36N.
		Northern twin	Castor	α	1	7	17	32	24N.
	Cancer	In Southern claw	Acubens	α	4	8	45	13	15N.
	Leo	Lyon's heart	Regulus	α	1	9	53	13	09N.
		In the Lyon's tail	Deneb	β	2	11	35	15	55N.
	Virgo	Virgin's ſpike		α	1	13	12	9	52 S.
	Scorpio	Scorpion's heart	Antares	α	1	16	14	25	51 S.
	Sagittarius	In the ſouthern part of the bow		ε	2	18	06	34	28 S.
Northern Constellations	Andromeda	In the girdle	Mirach	β	2	0	56	34	18N.
		In the foot	Almaach	γ	2	1	49	41	08N.
	Perseus	Meduſa's head	Algol	β	2	2	52	39	59N.
		In Perſius's ſide	Algenib	α	2	3	07	48	58N.
	Auriga	In the preceding ſhould.	Capella	α	1	4	59	45	43N.
	Bootes	The brighteſt	Arcturus	α	1	14	03	20	30N.
		In the following thigh	Mirach	ε	3	14	33	28	06N.
	North Crown	Brighteſt in the crown		α	2	15	22	27	33N.
	Eagle	Eagle's heart	Altair	α	2	19	39	8	14N.
	Pegasus	In Pegaſus's wing	Markab	α	2	22	53	13	53N.
		In Pegaſus's leg	Scheat	β	2	22	52	26	43N.
	Cassiopeia	In the breaſt	Schedar	α	3	0	27	55	11N.
	Great Bear	Upper pointer	Dubhe	α	2	10	46	63	03N.
		Lower pointer		β	2	10	45	57	41N.
		Firſt in the tail	Aliath	ε	2	12	41	57	18N.
		Laſt in the tail	Benetnasch	η	3	13	36	50	31N.
	Hercules	In the head	Ras Algethi	α	3	17	03	14	40N.
	Lyra	In the harp	Vega	α	1	18	29	38	34N.
	Swan	In the tail	Deneb	α	2	20	33	42	25N.
	Little Bear	Pole ſtar		α	2	0	42	88	00N.
Southern Constellations	Orion	Bright foot	Regel	β	1	5	01	8	28 S.
		Right ſhoulder	Betelgeuse	α	1	5	52	7	20N.
	Great Dog	In the mouth	Syrius	α	1	6	34	16	23 S.
	Little Dog	In the flank	Procyon	α	1	7	24	5	49N.
	Hydra	In the heart		α	2	9	16	7	37 S.
	South Fish	The brighteſt	Fomalhaut	α	1	22	42	30	55 S.
	Argo	In the waves	Canopus		1	6	18	52	33 S.
	Eridanus	The laſt	Acharnar	α	1	1	26	58	29 S.
	Centaurus	Brighteſt		α	1	14	13	59	46 S.

1055. *A* Table *for reducing the tables of the* Sun's declination *from the meridian of London to any other meridia*

Daily diff. of Declination	*Degrees of longitude from the meridian of London.*											
	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
min.	min.	min.	min.	min	min.	min.	min.	min.	min.	min.	min.	min.
2	00	00	00	00	00	00	01	01	01	01	01	01
3	00	00	00	00	01	01	01	01	01	01	01	01
4	00	00	00	01	01	01	01	01	02	02	02	02
5	00	00	01	01	01	01	01	02	02	02	02	02
6	00	00	01	01	01	01	02	02	02	02	03	03
7	00	01	01	01	01	02	02	02	03	03	03	03
8	00	01	01	01	02	02	02	03	03	03	04	04
9	00	01	01	01	02	02	03	03	03	04	04	04
10	00	01	01	02	02	02	03	03	04	04	05	05
11	00	01	01	02	02	03	03	04	04	05	05	05
12	00	01	01	02	02	03	03	04	04	05	05	06
13	01	01	02	02	03	03	04	04	05	05	06	06
14	01	01	02	02	03	03	04	05	05	06	06	07
15	01	01	02	02	03	04	04	05	06	06	07	07
16	01	01	02	03	03	04	05	05	06	07	07	08
17	01	01	02	03	04	04	05	06	06	07	08	08
18	01	01	02	03	04	04	05	06	07	07	08	09
19	01	02	02	03	04	05	06	06	07	08	09	09
20	01	02	02	03	04	05	06	07	07	08	09	10
21	01	02	03	03	04	05	06	07	08	09	10	10
22	01	02	03	04	05	05	06	07	08	09	10	11
23	01	02	03	04	05	06	07	08	09	10	11	11
24	01	02	03	04	05	06	07	08	09	10	11	12

1056. *A* Table *of* Refractions.

Alt. Deg.	Refr.		Alt. Deg.	Refr.		Alt. Deg.	Refr.		Alt. Deg.	Refr.		Alt. Deg.	Refr.		Alt. Deg.	Refr.		Alt. Deg.	Refr.	
	min.	ſec.		min.	ſec.		min.	ſec.		min.	ſec.		min.	ſec.		min.	ſec.		min.	
0	33	45	4	10	48	14	3	31	26	1	49	38	1	08	50	0	45	62	0	
0¼	30	24	4½	9	50	15	3	17	27	1	44	39	1	06	51	0	44	63	0	
0½	27	35	5	9	02	16	3	04	28	1	40	40	1	04	52	0	42	64	0	
0¾	25	11	5½	8	21	17	2	53	29	1	36	41	1	02	53	0	40	65	0	
1	23	07	6	7	4	18	2	43	30	1	32	42	1	00	54	0	39	66	0	
1¼	21	20	7	6	47	19	2	34	31	1	28	43	0	58	55	0	38	67	0	
1½	19	46	8	6	00	20	2	26	32	1	25	44	0	56	56	0	36	68	0	
1¾	18	22	9	5	22	21	2	18	33	1	22	45	0	54	57	0	35	69	0	
2	17	08	10	4	52	22	2	11	34	1	19	46	0	52	58	0	34	70	0	
2½	15	02	11	4	27	23	2	05	35	1	16	47	0	50	59	0	32	71	0	
3	13	20	12	4	03	24	1	59	36	1	13	48	0	48	60	0	31	72	0	
3½	11	57	13	3	47	25	1	54	37	1	11	49	0	47	61	0	30	73	0	

THE ELEMENTS OF NAVIGATION.

BOOK IX.

OF DAYS WORKS.

157. BY Days works is here meant the practical methods of finding a ſhip's place every day at noon, and ſettling the courſe d diſtance ſhe has then to ſail.

The navigator requires for this purpoſe the following elements, or ceſſary things to be known.

I. The means of meaſuring and correcting the run of the ſhip.
II. The nature and uſe of the ſea and azimuth compaſſes.
III. How to find the ſun's amplitude and azimuth.
IV. How to find the variation of the compaſs, and thereby to correct the courſes the ſhip has ſailed.
V. How to find the ſhip's lee-way, and thence correct the courſes.
VI. The nature and uſe of the inſtruments proper for taking the altitudes of celeſtial objects.
VII. To find the latitude by obſervation.
VIII. How to correct the current daily account of latitude and longitude.

SECTION I.

1058. *Of the meaſuring a ſhip's run.*

A great variety of methods have been propoſed to meaſure the rat at which a ſhip ſails, but that moſtly in uſe at this time, eſpecially amon the Engliſh, is by the *log* and *half minute glaſs.*

The LOG is a piece of thin board of a quadrantal form, loaded in th circular ſide with lead ſufficient to make it ſwim upright in the water To this is faſtened a line of about 150 fathoms long, called the LOG LINE, which is divided into certain ſpaces called knots; and the log-lin is wound on a reel which turns very eaſily.

The HALF MINUTE GLASS is of the make of an *hour glaſs*, and con tains ſuch a quantity of fine ſand as will run thro' the hole in its nec in half a minute of time.

The making of the experiment to find the velocity of the ſhip, i called HEAVING THE LOG, which is thus performed.

Two men hold the reel between them, and another holds the ha minute glaſs; an officer of the watch throws the log over the ſhip' ſtern, and when he obſerves the ſtray line is run off the reel (which i about 10 fathoms, this diſtance being uſually allowed to carry the lo out of the eddy of the ſhip's wake), and the firſt mark is going off, h cries *turn!* the glaſs holder anſwers *done!* who watching the glaſs, th moment it is run out ſays *ſtop!* the reel being immediately ſtopt, the la mark run off ſhews the number of knots, and the diſtance of that mar from the reel is eſtimated in fathoms: Then the knots and fathoms to gether ſhew the diſtance the ſhip has run the preceding hour, if the win has been conſtant.

In the King's ſhips, India ſhips, and ſome others, it is uſual to heav the log every hour: But coaſters, and thoſe uſing ſhort voyages, heav the log once in two hours only.

1059. This practice of meaſuring a ſhip's rate of ſailing, is founde upon the following principle.

That *the length of each knot, ought to be the ſame part of a ſea mile as half a minute is, of an hour.*

Therefore the length of each knot ſhould be either

$(\frac{1}{2} \times \frac{1}{60} =)$ $\frac{1}{120}$ of a nautical mile.

Or $(\frac{1}{2} \times \frac{1}{60} \times \frac{1}{60} =)$ $\frac{1}{7200}$ of a degree.

Or $(\frac{1}{2} \times \frac{1}{60} \times \frac{1}{60} \times \frac{1}{360} =)$ $\frac{1}{2592000}$ of a great circle of the earth.

By Mr. Richard Norwood's experiment (ſee art. 900), it appears tha a degree of a great circle on the earth contains 367200 Engliſh feet and $\frac{1}{60}$th thereof, or 6120 feet, are in one nautical mile.

Hence $\frac{1}{120}$th of 6120, or 51 feet, ſhould be the length of each kno But becauſe it is ſafer to have the reckoning rather before the ſhi than after it, therefore 50 feet may be taken as the proper length c each knot.

And as moſt men can conveniently fathom with their arms abou 5 feet; ſo a knot may be ſuppoſed to conſiſt of 10 fathoms, each o 5 feet.

Th

The length of the knots in the log-line uſed formerly were only of 42 feet; and it is much to be wiſhed that not any line ſo divided was now in uſe, but cuſtom in many things prevails over reaſon: This way of dividing the log-line was founded on the ſuppoſition that 60 miles, each of 5000 Engliſh feet, made a degree; for $\frac{1}{120}$th of 5000 is $41\frac{2}{3}$, or in round numbers 42 feet. And altho' many mariners find by experience that this length of the knot is too ſhort, yet rather than quit the *old way*, they uſe glaſſes for half minute ones that run but 24 or 25 ſeconds.

The method uſually recommended to try if the glaſſes be accurate, is: On a round nail or peg, hang a ſtring that has a muſket ball fixed to one end, carefully meaſuring between the centre of the ball and the ſtring's loop over the peg $39\frac{1}{8}$ inches: Then ſwing it, and count one for every time it paſſes under the peg, and the number of ſwings made during the time the glaſs is running out, ſhews the ſeconds it contains.

For experience ſhews, that the length of a ſecond pendulum is about $39\frac{1}{8}$ inches.

The diſtance given by the log may be wrong on three accounts, namely, by there being an error either in the glaſs, or log, or in both.

1060. Case I. *When the log-line is truly divided, and the glaſs is faulty.*

Rule. As the ſeconds run by the glaſs, is to 30 ſeconds:
So is the diſtance run by the log, to the true diſtance.

Exam. *Suppoſe a ſhip ſails at the rate of $6\frac{1}{2}$ knots while a glaſs runs out, which is but 25 ſeconds: What is the true rate of ſailing?*

As 25 : 30 :: 6,5 : 7,8 miles, the true diſtance ſailed in an hour.

1061. Case II. *When the glaſs is true, and the log-line is faulty.*

Rule. As 50 feet, is to the diſtance meaſured between knot and knot:
So is the diſtance run by the log, to the true diſtance.

Exam. *Suppoſe a ſhip ſails at the rate of $6\frac{1}{2}$ knots an hour, by a log-line which has only 44 feet to a knot: What is the true rate of ſailing?*

As 50 : 44 :: 6,5 : 5,72 miles, the true diſtance ſailed in an hour.

1062. Case III. *When both log-line and glaſs are faulty.*

Rule. Multiply thrice the meaſured length of a knot by the diſtance run per log; the product divided by five times the meaſured time of the glaſs, will give the true diſtance run.

Exam. *Suppoſe a ſhip runs 5 knots an hour, by a log-line of 45 feet to a knot, and a glaſs of 25 ſeconds: What is the true rate of ſailing?*

Then $3 \times 45 \times 5$, and divided by 5×25, gives 5,4 miles = true diſt.

For ſuppoſe K = meaſ. length of a knot; G = ſeconds per glaſs; D = run per log.

Then $G : 30 :: D : 30 \times D \div G$ = diſt. run by a correct glaſs. (1060)

And $50 : K :: 30 \times D \div G : 30 \times D \times K \div G \times 50 = 3 \times D \times K \div 5 \times G$. (1061)

Note, The mark ÷ ſignifies divided by.

SECTION II.

Of the Mariner's compaſs.

1063. The MARINER's COMPASS is an inſtrument uſed at ſea to ſhew or point out the way a ſhip is to go; and conſiſts of three parts, namel the box, the card or fly, and the needle.

The BOX, which contains the card and needle, is a circular braſs bo hung within a ſquare wooden one, by two concentric rings, ſo fixed b croſs centres to the two boxes, that the inner one, or compaſs box, ſha retain an horizontal poſition in all motions of the ſhip.

The CARD or FLY is a circle of ſtiff paper repreſenting the horizon and is divided into points and quarter points of the compaſs.

The NEEDLE is a piece of ſteel made magnetical; whereby it ha the property of pointing one of its ends towards the north pole of th world.

The needle is fixed to the underſide of the card, and in the centre i placed a conical ſocket, which is put on an upright pointed pin fixed i the bottom of the box; ſo that the card hanging on the pin, turns freel round its centre; one of the points being, by the property of the needle always directed towards the north pole.

The top of the box is covered with a glaſs plane, whereby the car in its motion is not diſturbed by the wind. And this apparatus together is called the Compaſs.

1064. Before the invention of the compaſs, which is between 300 an 400 years ago, the navigating of ſhips was a very tedious and precarious operation: But the compaſs enables the mariner to hold his courſ over the ſeas in as direct and true a tract, as the land carrier directs hi carriage in a well beaten road. Hence it might be reaſonably imagined, that no neceſſary expence or care ſhould ever be wanting in the conſtruction of this moſt uſeful inſtrument: But it has ſo happened, that ſcarce one ſea compaſs in ten is fit for the uſe for which it is made; and thi has aroſe from their being fabricated by unſkilful and ignorant workmen for the wholeſale dealers in the ſhipping way; who generally pay no more regard to the conſtruction of this inſtrument, whereon the ſucceſs of the voyage and the lives of the men in a great meaſure depend, than they do to any indifferent thing of the ſame price.

There are however compaſſes uſed in the Royal Navy, and ſome few trading ſhips, which are conſtructed with more care, and on better principles; and are therefore vaſtly preferable to thoſe commonly uſed in the merchant's ſervice, which from their compoſition ſeem as tho' they had been contrived purpoſely to vary from what was to be expected of them: Such as joining the outſide box together with iron nails; making the needle of ſoft wire, and diſpoſing it in the form of a rhombus, in expectation that the magnetical forces of the ſides would conſpire to act in the diagonal: Making the pin and ſocket ſo badly, as to prevent the traverſing of the card, *&c.* *&c.*

But it muſt be obſerved, that it is only within a very few years that ſea compaſſes have been made free from the multitude of inconveniences to which the beſt conſtructed of them were liable before; Such as, firſt, needles having ſeveral poles, occaſioned by their irregular ſhape, the beſt kind being ſtrait bars with flat ends. 2d. The needles being made of ſuch a temper as was neither ſuſceptible of receiving, or retaining half the virtue it was poſſible to give them; and conſequently they were not with due ſtrength and perſeverance directed towards the poles of the world. 3d. The want of proper means to reſtore their loſs of magnetiſm while on a voyage. 4th. The troubleſome and inaccurate methods of rectifying a damaged pin on which the card turned, together with the expence attending the uſe of agate caps or ſockets, than which none are ſo proper. 5th. The want of proper contrivances to hinder the card from being affected by the various motions of the ſhip. Theſe, and ſeveral other imperfections, have been happily removed by the labours of the truly celebrated *Dr. Gowen Knight*, F. R. S. whoſe admirable invention of giving magnetiſm to ſteel bars, greatly ſuperior to any power they could derive from the natural loadſtones, joined to a multitude of experiments which he has made for the marine ſervice, have produced the means of conſtructing ſea compaſſes ſo perfect, that there ſeems nothing farther to be wiſhed for as neceſſary to this inſtrument. It may be reaſonably expected that ſuch correct compaſſes will readily come into general uſe, as there have been ſeveral trials made of them both in men of war and merchantmen: But, like ſeveral other uſeful improvements, it muſt wait till time has removed old prejudices.

1065. After the diſcovery of that moſt uſeful property of the magnet, namely, the giving hardened iron and ſteel a polarity, the compaſs was for many years uſed without knowing that its direction in any wiſe deviated from the poles of the world: And about 200 years ago, ſo certain were ſome of its inflexibly pointing to the north, that they treated with contempt the notion of the variation, which about that time began to be ſuſpected. However, careful obſervations ſoon diſcovered that in England, and its neighbourhood, the needle pointed to the eaſtward of the true north: But the quantity of this deviation being known, mariners became as well ſatisfied as if the compaſs had none; becauſe they imagined that the true courſe could be obtained by making allowance for the true variation.

From ſucceſſive obſervations made afterwards, it was found that the deviation of the needle from the north was not a conſtant quantity; but that it gradually diminiſhed, and at laſt, namely about the year 1660, it was found at London that the needle pointed due north, and has ever ſince been getting to the weſtward, and now the variation is more than 18 degrees to the weſtward of the north: So that it may be ſuſpected the variation has a kind of libratory motion, traverſing thro' the north to unknown limits eaſtward and weſtward. But the ſettling of this point muſt be left to time.

During the time of the ſaid obſervations it was alſo diſcovered, that the variation of the needle was different in different parts of the world, it being weſt in ſome places when it was eaſt in others; and in places where the variation was of the ſame name, yet the quantity of it greatly differed. It was therefore found neceſſary that mariners ſhould every day, or as often as they had opportunity, make proper obſervations for an amplitude or azimuth, whereby they might be enabled to find the variation of the compaſs in their preſent place, and thence correct their courſes.

1066. Beſide the common ſea compaſs, there is another called the AZIMUTH COMPASS, whoſe uſe is to take the bearing of any celeſtial object, either when it is at, or above the horizon. This compaſs in no reſpect differs from the other, only the circumference of the card or box is divided into degrees; and there is fitted to the box an index with two ſights, which are upright pieces of braſs placed diametrically oppoſite, having ſlits down their middles, thro' which the ſun or ſtar is to be viewed at the time of obſervation.

PROBLEM.

To make an obſervation with the Azimuth compaſs.

1067. I. FOR AN AMPLITUDE *.

Move the box about till the four cardinal points of the card coincide with the four lines in the ſides of the compaſs box; keep the box ſteady, and turn the index till the ſun at its riſing or ſetting is ſeen thro' both the ſights: Then the degrees intercepted between the north point of the compaſs and that end of the index pointing to the ſun, will be the magnetic amplitude ſought.

1068. II. FOR AN AZIMUTH †.

Set the box ſo, that the four cardinal points of the card ſtand oppoſite to the four lines in the compaſs box; hold the box in this poſition, and move the index till (the ſights being directed to the ſun) the ſhadow of the ſtring joining the ſights falls directly along the middle line of the index: Then the degrees in the arc, intercepted between that end of the index next the ſun and the north point of the card, will give the magnetic azimuth required.

If the ſun does not ſhine ſtrong enough to give a diſtinct ſhadow, look thro' one of the ſights, and move the index till the ſtring cuts the ſun's centre; and then the intercepted arc, as before, ſhews the ſun's azimuth.

What is here ſaid of the ſun, is in like manner to be applied to the ſtars.

1069. When there is a rough ſea, and the ſhip yaws much, the obſervation is beſt performed by two perſons, thus:

Let one look thro' the ſights, and turn them till the thread cuts the centre of the ſun, and be ſure to keep a conſtant ſight of it notwithſtanding the motion of the ſhip, which being ſignified to the aſſiſtant by any word, let him that inſtant obſerve what degree of the card is under the middle line of the ſights, and the arc intercepted between that point and the meridian will ſhew the quantity of the magnetic amplitude or azimuth. If the card ſhould vibrate very much, let him take the middle degree between the limits to which the vibration reaches.

When the magnetic azimuth of any object is obſerved, its altitude muſt alſo be taken at the ſame time.

This inſtrument is alſo uſeful in ſetting the ſhip's wake, in order to find the leeway; and alſo to find the bearings of headlands and other objects.

---

* Amplitudes, are from obſervations made on objects when in the horizon. See articles 939, 986 to 992.

† Azimuths, are from obſervations made on objects when above the horizon. See articles 938, 993.

SECTION III.

1070. *To work an Amplitude.*

The true amplitude of a celeſtial object, is its diſtance from one of the cardinal points of the horizon, at the riſing or ſetting of that object.

The amplitude is reckoned eaſtward in the morning; but it is named weſtward in the evening.

The cuſtomary way of accounting the amplitude is, in the morning to reckon it ſo much to the ſouthward or northward of the eaſt; and in the evening ſo much to the ſouthward or northward of the weſt: But as bearings are generally taken from the meridian, therefore in the following pages the amplitudes will be chiefly eſtimated from the north point of the horizon.

The finding of the true amplitude at ſea is of conſiderable importance in navigation; for the true courſes the ſhip has ſteered is partly aſcertained thereby.

1071. PROBLEM.

Given the latitude of the place, and the declination of a celeſtial object: Required the true amplitude of that object.

SOLUTION.

Say: As the co-ſine of the latitude,
To Radius;
So ſine of the given declination,
To the ſine of an horizontal arc.

Which arc taken from 90 degrees, if the declination is north, will give the ſun's true amplitude from the north point of the horizon: But if the declination is ſouth, that arc added to 90 degrees gives the amplitude from the north.

When the amplitude is reckoned from the eaſt or weſt points of the horizon; then the ſaid horizontal arc is the true amplitude, and is to be taken to the northward of thoſe points, when the declination is north: But to the ſouthward, when the declination is ſouth.

1072. SOLUTION BY THE TRAVERSE TABLE.

With the declination among the courſes, find the departure to the diſtance 100.

With the given latitude among the courſes, and ſaid departure in column of latitude, find the diſtance.

In a column of departure, find the ſaid diſtance againſt 100 in the column of diſtance, and the degrees in the correſponding courſe will give the horizontal arc ſought.

This rule will always give the degrees as truly as by logarithms: And as the magnetic amplitude can be obſerved to degrees only by the compaſs, the true amplitude will be had ſufficiently correct by this rule.

Exam. I. *What is the ſun's true amplitude on the 14th day of Ma 1753, in the latitude of 38° 25′ N.?*

By Logarithms.

As coſ. lat.	=	38°	25′	0,10595
To Radius	=	R		10,00000
So ſin. decl.	=	18	44	9,50673
To ſin. hor. arc	=	24	12	9,61268
Subtract from		90	00	for N. dec.
Leaves true amp.	=	65	48	from N.

By the Traverſe table.

To decl. 18° 45′, and diſt. 100, th dep. is 32.

To lat. 38° 25′, and diff. lat. 32, th diſt. is 41.

To diſt. 100, and dep. 41, the cour is 24° 15′. Therefore the horizontal arc is 24°.

In this and the following examples, the neareſt deg. and min. to th declin. that can be found in the Traverſe table, is taken for the declin

Exam. II. *Required the ſun's true amplitude in the lat. of 51° 32′ N. on the 25th day of November, 1753?*

By Logarithms.

As coſ. lat.	=	51°	32′	0,20617
To Radius	=	R		10,00000
So ſin. decl.	=	20	52	9,55169
To ſin. hor. arc	=	34	56	9,75786
Add to		90	00	for S. decl.
Gives true amp.	=	124	56	fr. the N.

By Traverſe table.

To decl. 20° 45′, and diſt. 100, th dep. is 35,4.

To lat. 51° 30′, and diff. lat. 35,4, th diſt. is 57.

To diſt. 100, and dep. 57, the cour is 34° 48′. Therefore 35° ma be taken for the horizontal ar ſought.

Exam. III. *On the 20th of January, 1753, what was the ſun's amplitud at the Cape of Good Hope, in lat. 34° 15′ S.*

By Logarithms.

As coſ. lat.	=	34°	15′	0,08271
To Radius	=	R		10,00000
So ſin. decl.	=	20	01	9,53440
To ſin. hor. arc	=	24	28	9,61711
Which add to		90	00	for S. decl.
Gives true amp.	=	114	28	fr. the N.

By Traverſe table.

To decl. 20° 00′, and diſt. 100, th dep. is 34,3.

To lat. 34° 15′, and diff. lat. 34,3 the diſt. is 41,5.

To diſt. 100, and dep. 41,5, the courſe is 24° 37′. Therefore 24° ma be taken for the horizontal arc ſought.

Exam. IV. *On what point of the horizon does the ſtar Arcturus riſe an ſet at Buenos Aires in lat. 34° 35′ S.?*

By Logarithms.

As coſ. lat.	=	34°	35′	0,08444
To Radius	=	R		10,00000
So ſin. decl.	=	20	30	9,54432
To ſin. hor. arc	=	25	10	9,62876
Which add to		90	00	for S. dec.
Gives true amp.	=	115	10	fr. the N.

By Traverſe table.

To decl. 20° 30′, and diſt. 100, th dep. is 34,8.

To lat. 34° 30′, and diff. lat. 34,8 the diſt. is 42.

To diſt. 100, and dep. 42, the courſe is 25° 00′. Therefore the horizontal arc may be taken as 25 degrees.

SECTION IV.

1073. *To work an Azimuth.*

The true azimuth of a celeſtial object, is its bearing, when above he horizon, from the north or ſouth points thereof.

In the forenoon the azimuth is reckoned eaſtward, and in the afternoon weſtward.

The azimuth is uſually eſtimated from the ſouth, when to the ſouthward of the eaſt or weſt points of the horizon; and when to the northward of thoſe points, it is reckoned from the north: But it may be more convenient to account it always from the north.

The uſe of the azimuth is to find the variation of the compaſs, in order to correct the courſes the ſhip has ſteered.

1074. PROBLEM.

The latitude of the place, the declination of the object, and its altitude eing known: Required the true azimuth of that object.

SOLUTION.

When the latitude and declination are of the ſame name, let the co-declination be called A.

But when of contrary names, add the declination to 90 deg., and call he ſum A.

Let the difference between the co-lat. and co-alt. be called D.

Alſo, find the half ſum and half difference of A and D.

Then write down theſe four logarithms under one another.

Namely: The arith. comp. of the log. ſine of the co-latitude.
The arith. comp. of the log. ſine of the co-altitude.
The logarithm ſine of the foreſaid half ſum of A and D.
The logarithm ſine of the foreſaid half diff. of A and D.

Add the four logarithms together, and take half their ſum, which ſeek mong the ſines for the correſponding degrees and minutes, and theſe eing doubled will give the true azimuth required.

And is to be reckoned from the north, in north latitude.

But in ſouth latitude, take thoſe degrees from 180°, and the remainder ill give the true azimuth from the north.

The working of an azimuth by logarithms, altho' as ſhort as any umeral ſolution can be expected, is one of the moſt tedious elements at enter into a day's work: But by Gunter's ſcale it may be readily one, ſufficiently correct.

075. *To work an azimuth by the Gunter's ſcale.*

Find the co-lat., co-alt., the half ſum, and half difference as above.

Then, On the ſcale of log. ſines, ſet one point of the compaſſes on e half ſum, extend the other point to the co-lat., obſerving whether e ſecond point falls to the right or left of the firſt, and take the compaſſes off, without altering their extent.

Set one point on the co-alt., and let the ſecond point fall where it will he ſame way it did before), there fix it, and open the compaſſes till the ther point falls on the half difference, then take them off without altering their extent.

Now ſet one point of the compaſſes on the braſs pin at the beginning or right hand end of the ſcale of verſed ſines (marked V. S.), tur the other point to the left, and obſerve what degrees and minutes in th verſed ſines it falls on; thoſe degrees and minutes will be the azimuth if the latitude is ſouth: But if north, take them from 180°, and the remainder is the azimuth ſought.

If the firſt extent, when applied from the co-alt. to a fourth, ſhoul reach beyond the right hand end of the ſcale, as it will ſometimes happen then hold the Gunter flat on a board, and thereon let the over point reſt and thence take the extent to the half difference, and work as before.

Theſe directions, with thoſe at articles 379 and 380, will remove a the ſeeming difficulties that beginners may meet with in working an azimuth by the Gunter's ſcale.

Exam. I. *Being at ſea, in latitude 40° 28′ N., in the afternoon the ſun altitude was obſerved to be 20° 46′, when his declination was 17° 10′ S. Required the ſun's true azimuth at that time?*

The co-alt. is 69° 14′
The co-lat. is 49 22

The diff. D = 19 52

Now 107° 10′ = A = 90° & decl.
And 19 52 = D.

127 02 | 63° 31′ = ½ ſum.
2)
87 18 | 43 39 = ½ diff.

By Logarithms.

Ar. co-log. ſin. co-lat. =	49°	22′	0,1198
Ar. co-log. ſin. co-alt. =	69	14	0,0291
Log. ſin. ½ ſum =	63	31	9,9517
Log. ſin. ½ diff. =	43	39	9,8390

The ſum of the four logs. 19,9397

Their ½ ſum, gives 68° 55′ 9,9698

The double, is 137 50, which is the ſun true azim. from the N. point of the horizon

By Gunter's ſcale.

On the ſines, the extent from 63° 31′ to 49° 22′, will reach from 69 14′ to a little more than 52°: Let the point reſt there, and extend th other to 43° 39′; this extent will reach from the beginning of the verſe ſines to about 42°, which taken from 180° leaves 138° for the azimuth and is very near what was found by the logarithms.

Exam. II. *What is the ſun's true azimuth in the latitude of 26° 30′ N. when his altitude in the forenoon is 24° 28′, and his decl. is 22° 40′ N.?*

The co-alt. is 65° 32′
The co-lat. is 63 30

The diff. D = 2 02

Now 67° 20′ = A, is 90° leſs [decl.
And 2 02 = D.

69 22 | 34° 41′ = ½ ſum.
2)
65 18 | 32 39 = ½ diff.

By Logarithms.

Ar. co-log. ſine co-lat. =	63°	30′	0,0482
Ar. co-log. ſine co-alt. =	65	32	0,0408
Log ſine ½ ſum =	34	41	9,7551
Log. ſine ½ diff. =	32	39	9,7320

The ſum of the four logs. 19,5762

Their ½ ſum, gives 37° 52′ 9,7881

The double, is 75 44, which is the ſun true azim. from the north point of the compaſ

By Gunter's ſcale.

On the log. ſines, the extent from 34° 41′ to 63° 30′, will reach from 65° 32′ to ſome point beyond the right hand end of the ſcale; let the point reſt there, and extend the other point to the ſine of 32° 39′, and this extent will, on the verſed ſines, reach from the beginning, or 0 deg., to 104° 20′, whoſe ſupplement 75° 40′ is the azimuth, nearly, as found by logarithms.

Exam. III. *At the Iſland of St. Helena, in lat.* 16° 00′ *S., the ſun's altitude was obſerved in the forenoon to be* 30° 22′, *when his declination was* 22° 58′ *S.: What was the ſun's azimuth at that time?*

The co-lat. is 74° 00′
The co-alt. is 59 38
The diff. D = 14 22

Now 67° 02′ = A, is 90° leſs [decl.
And 14 22 = D.

81 24 | 40° 42′ = ½ ſum.
2) 52 40 | 26 20 = ½ diff.

Ar. co-log. ſine co-lat. =	74°	00′	0,01716
Ar. co-log. ſine co alt. =	59	38	0,06409
Log. ſine ½ ſum =	40	42	9,81431
Log. ſine ½ diff. =	26	20	9,64698
The ſum of the four logs.			19,54254
Their ½ ſum, gives	36°	12′	9,77127

Which doubled, is 72 24, for the ſun's true azim. from the ſouth, or 107° 36′ from north.

Or thus: The extent from 40° 42′ to 74° 00′ on the ſines, will reach rom the ſine of 59° 38′ to a point beyond the limits of the ſcale; then he extent from that point to the ſine of 26° 20′ will, on the verſed ſines, each from 0 deg. to about 107° 40′, the azimuth from the north.

Exam. IV. *On what point of the horizon, at the Cape of Good Hope, oes the ſtar Aldebaran bear, when its altitude is* 22° 25′?

he co-alt. is 67° 35′
he co-lat. is 55 45
he diff. D = 11 50

Now 105° 59′ = A, is 90° & decl.
And 11 50 = D.

117 49 | 58° 54′ = ½ ſum.
2) 94 09 | 47 05 = ½ diff.

Ar. co-log. ſin. co-lat. =	55°	45′	0,08271
Ar. co-log ſin. co-alt. =	67	35	0,03412
Log. ſin. ½ ſum =	58	54	9,93261
Log. ſin. ½ diff. =	47	05	9,86472
The ſum of the four logs.			19,91416
Their ½ ſum, gives	64°	57′	9,95708

Which doubled, is 129 54, for the ſun's true azim. from the ſouth, or 50° 06′ from the N.

Or thus: The extent from about 59° to about 67½° on the ſines reaches om about 55¾° to about 63°: Then the extent from about 63° to about 7°, reaches from the beginning of the verſed ſines to about 50° for the imuth ſought.

Theſe examples ſufficiently ſhew, that an azimuth may be worked by ie Gunter's ſcale, not only with great readineſs, but alſo as accurately the magnetic azimuth can be taken by the compaſs.

The manner of working amplitudes and azimuths have been pretty rgely inſiſted on, in order to render them familiar to mariners; who, for e generality, eſteem theſe operations as very troubleſome; and it is on is account that many writers have contrived various tables to remove the mplained of trouble: But from a due conſideration of what is here done, is apprehended ſuch tables will not hereafter be ſo much wanted.

SECTION V.

1076. *Of the Variation of the Compaſs.*

The *magnetic poles*, are thoſe points of the world, towards which th north and ſouth ends of the needle in the ſea compaſs are directed.

Magnetical meridians, are imaginary lines paſſing thro' the magneti poles.

The *variation of the compaſs*, is the difference between the bearings o the *true* and *magnetic* north poles; and is meaſured by an arc of the horizon contained between the true and magnetic points thereof.

The variation is named *eaſt*, when the magnetic north point is to th eaſtward of the true north: But when to the weſtward, it is named *weſt* variation.

The magnetic amplitude of a celeſtial object, is its bearing by th compaſs when in the horizon.

The magnetic azimuth of a celeſtial object, is its bearing by th compaſs when above the horizon.

The variation is found by comparing together the true and magneti amplitudes or azimuths of celeſtial objects.

The uſe of the variation is to correct the courſes a ſhip has ſteere by the compaſs.

1077. PROBLEM.

Given the true and magnetic amplitudes, or azimuths, of a celeſtial object: Required the variation of the compaſs.

SOLUTION.

Let the true and magnetic amplitudes, or azimuths, be reckone from the north; and named eaſt when the obſervation is made in th forenoon; but when made in the afternoon, let it be named weſt.

Then the difference between the true and magnetic amplitudes, o azimuths, is the variation of the compaſs.

And is of the ſame name as the true amplitude, or azimuth, if th true is greater than the magnetic: But when the true is leſs than th magnetic, the variation is of a contrary name to the true amplitude, o azimuth.

For, let N repreſent the true north point of the horizon, and the ar NWO the true amplitude or azimuth: Now it is evident, that if the ar OW*n*, repreſenting the magnetic amplitude or azimuth, be leſs tha OWN; then the magnetic north point of the compaſs will fall on the ſam ſide the true north, that the amplitude or azimuth is on: But whe greater, *n* falls on the contrary ſide. Plate XI. Fig. 8.

Exam. I. *The ſun was obſerved to riſe 70° from the north by the ſea compaſs, when his true amplitude was N. 81° 45′ E.: What was the variation, and which way?*

True amplitude = 81° 45′ E.
Magnetic amplitude = 70 00

The variation = 11 45 E.

Exam. II. *The ſun was obſerved by the compaſs to ſet WSW. when his true amplitude was N. 126° 17′ W.: Required the variation of the compaſs, and which way?*

True amplitude = 126° 17′ W.
Mag. amplitude = 112 30 = 10 pts.

The variation = 13 47 W.

Exam. III. *Suppoſe the ſun's true azimuth to be N. 84° 40′ W., when by the compaſs his bearing was W. b. S.: Required the quantity and quality of the variation?*

True azimuth = 84° 40′ W.
Mag. azimuth = 101 15 = 9 pts.

The variation = 16 35 E.

Exam. IV. *When the ſun was obſerved to bear ESE., his true azimuth was found to be N. 88° 46′ E.: What was the quantity and name of the variation?*

True azimuth = 88° 46′ E.
Magnetic azim. = 112 30

The variation = 23 44 W.

The manner of finding the variation being known, the courſes may be corrected by the following rules.

1078. PROBLEM.

Given the courſe ſet, and the variation of the compaſs:
Required the true courſe the ſhip ſteers.

Solution.

If the variation is weſt, call the NW. quarter the 1ſt, the SW. the 2d, the SE. the 3d, and the NE. the 4th: But if the variation be eaſt, call the NE. quarter the 1ſt, the SE. the 2d, the SW. the 3d, and the NW. the 4th.

Then, if the courſe ſet be in the firſt or third quarters, add the variation to the points or degrees in the given courſe: But if in the ſecond or fourth quarters, ſubtract; and the ſum in the former, or difference in the latter caſe, will be the courſe corrected by the variation *.

Exam. I. *Suppoſe the variation is 1½ point W.; to correct theſe courſes, NNW.; SW. ½ W.; SE. b. S. ¾ E.; ENE. ¼ E.?*

Courſes ſet	NNW.	2 pts.	SW. ½ W.	4½ pts	SE. b. S. ¾ E.	3¾ pts	ENE. ¼ E.	6¼
Variation	Add	1½ pts.	Subtr.	1½	Add	1½	Subtract	1½
Cor. cou.	NW. b. N. ½ W.	3½ pts	SW. b. S.	3	SE. b. E. ¼ E.	5¼	NE. ¾ E.	4¾

Exam. II. *The variation is 18° E.; to correct the following courſes?*

Courſes ſet	NE. b. N.	= 33° 45′	S. b. E.	= 11° 15′	SW. b. W.	= 56° 15′	NW.	= 45° 00′
Variation	Add	18 00	Subt.	18 00	Add	18 00	Subt.	18 00
Cor. cour.	N.	51 45 E.	S.	6 45 W	S.	74 15 W	N.	27 00 W

---

* For where the compaſs has a variation, the courſe ſet is not ſo far removed from the true north as it ſhould be, by the quantity of the variation: But the quantity of the variation being added in the 1ſt and 3d quadrants, and ſubtracted in the 2d and 4th, puts the courſe ſo much farther from the true north, counting from thence, the ſame way with the variation, round the compaſs.

SECTION VI.

1079. *Of finding the Ship's drift, or leeway.*

When a ſhip turns to windward, or is cloſe hauled on a wind, ſh generally runs to the leeward of her intended courſe.

Leeway is the angle which the ſhip's real courſe makes with her intended courſe, occaſioned by contrary winds and a rough ſea.

The leeway made by different ſhips, under the ſame circumſtances o wind and ſails, will be different; and even the ſame ſhip, with differen lading, and having more or leſs ſail abroad, will make more or leſs leeway However, the following precepts for allowing for the leeway have bee generally given by moſt writers on this ſubject within the laſt 50 years they were given by Mr. John Buckler to Mr. William Jones, who fir publiſhed them about the year 1702.

1080. *Allowances for Leeway.*

I. When a ſhip is cloſe hauled, has all her ſails ſet, the water ſmooth, an a moderate gale of wind, ſhe is then ſuppoſed to make little or no leeway.

II. Allow one point, when it blows ſo freſh that the ſmall ſails are taken in.

III. Allow two points, when the top-ſails muſt be cloſe reeft.

IV. Allow two and a half points, when one top-ſail muſt be handed.

V. Allow three and a half points, when both top-ſails are to be taken in.

VI. Allow four points, when the fore courſe is handed.

VII. Allow five points, when trying under the main-ſail only.

VIII. Allow ſix points, when both main and fore courſes are taken in.

IX. Allow ſeven points, when the ſhip tries a hull, or all ſails handed.

When the wind has blown hard in either quarter, and ſhifts acroſs the meridian into the next quarter, the leeway will be leſſened.

But in all theſe caſes, reſpect muſt be had to the roughneſs of the ſea, with the trim of the ſhip; and hence the mariner will be able to correc his courſe.

1081. PROBLEM.

Given the place of the wind, the courſe ſet, and the leeway: Required the true courſe the ſhip makes.

Rule. Count the neareſt way of the compaſs from the wind to the courſe ſet, and as much beyond as is the leeway, and it gives the point for the true courſe.

Exam. I. *The wind NW. b. N., the courſe ſet NE. b. N., leeway 1 point: What is the courſe made good?*

The wind NW. b. N.
Courſe ſet NE. b. N. = 3 points.
Add the leeway = 1 point.
True courſe NE. = 4 points.

Here, counting the neareſt way in the compaſs from NW. b. N. to NE. b N., the leeway going beyond it towards the eaſt muſt be added to drive it ſo much farther from the wind.

Exam. II. *The wind SE. b. S., a ſhip is cloſe hauled with her ſtarboard tacks aboard, and both top-ſails handed: What is her true courſe?*

The wind SE. b. S.
Courſe ſet E. b. N. = 7 points.
Subtract leeway = $3\frac{1}{2}$ points.
True cou. NE. b N. $\frac{1}{2}$ E. = $3\frac{1}{2}$ points.

The ſhip being cloſe hauled, is ſuppoſed 6 pts. from the wind, and muſt be in the NE. quarter, being on the ſtarb. tacks: Then counting 6 pts. from SE. b. S., gives E. b. N. 7 points; from which the leeway is to be taken.

SECTION VII.

Of Inſtruments for taking of Altitudes.

The altitude of the ſun, or any other celeſtial object, may be taken by inſtruments contrived after various ways; thoſe only, beſt adapted for uſe at ſea, will be here conſidered.

1082. *The deſcription and uſe of Davis's quadrant.* Plate XI. Fig. 9.

The inſtrument moſt in uſe at ſea, by us called DAVIS's * QUADRANT, and by foreigners the ENGLISH QUADRANT, conſiſts of two arches (making together ninety degrees, and therefore called a quadrant), fixed and braced, the one above, the other below a ſtrait bar, whoſe length is equal to the radius of the lower arch, and is about thrice the length of the radius of the upper arch.

The upper, or, as it is commonly called, the GREATER ARCH, uſually contains 65 degrees, not ſubdivided into ſmaller parts; and the LESSER ARCH contains 25 degrees, which on account of their larger ſize are ſubdivided into ſmaller parts, ſuch as $\frac{1}{3}$ or $\frac{1}{6}$ parts of degrees; and theſe by the help of diagonal diviſions, and 10 concentric circles, are uſually ſubdivided ſo, as to ſhew every one or two minutes.

There are three pieces called vanes, ſo fitted to the inſtrument as to ſtand at right angles to its plane.

Firſt, The HORIZON VANE is fitted to ſlip on the end of the bar or radius, cloſe to the centre of the two arches: In this vane there is a long ſlit, thro' which is to be ſeen the horizon, that is the line where he ſky and water apparently meet.

Secondly, The SIGHT VANE, which is ſo fitted as to ſlide along the eſſer, or 25 arch, having a ſharp edge to cut the diviſion it ſtands at; and in a line with this edge is a ſmall hole, thro' which the horizon is o be ſeen thro' the ſlit in the horizon vane.

Thirdly, The SHADE VANE, which is fitted to ſlide on the greater, or 65 arch: The upper line of the ſhade caſt by this vane is to fall on he edge of the ſlit in the horizon vane during the time of obſervation.

Inſtead of the ſhade vane there is generally uſed one called the GLASS VANE, it having a convex lens (or as uſually called a burning glaſs) fitted o it, which collects the ſun's rays into a bright ſpot on the horizon ane.

AB, is the bar or radius. BC, the leſſer or 25 arch. DE, the greater or 65 arch. *ab*, *cg*, *hi*, are braces which fix the arches to the radius. G the horizon vane. H the ſight vane. F the ſhade or glaſs ane. ☉FA a ray of the ſun. ∠DAC a right angle, or 90°.

---

* The inſtrument now called *Davis's quadrant*, is ſomewhat different from hat mentioned by Capt. *John Davis* in his treatiſe called the Seaman's ſecrets, ubliſhed in the year 1594.

1083. *To obſerve the ſun's altitude or zenith diſtance by Davis's quadran*

Firſt. Put on the horizon vane cloſe to the ſhoulder or notch at A in the bar AB: Set the ſhade or glaſs vane on the arch DE to an eve degree, about 10 or 15 degrees leſs than what the zenith diſtance ma be then gueſſed at; and put the ſight vane H about the middle of the arc BC; obſerving that the ſhade and ſight vanes be thruſt cloſe to the back of the arches.

Secondly. Turn your back to the ſun, hold the plane of the inſtrumen in an upright poſition, look thro' the hole in the ſight vane, and raiſ or lower the quadrant until the bright ſpot, caſt by the ſun thro' the glaſ vane, falls on the ⊖ in the line drawn thro' the ſlit in the horizon vane then if the horizon is ſeen thro' the ſlit in the horizon vane, even with th ⊖, the quadrant will give the ſun's altitude or zenith diſtance at that time

Thirdly. But if the ſky appears thro' the ſlit inſtead of the horizon ſlide the ſight vane H higher, till the horizon coincides with ⊖; and i the ſea appears inſtead of the horizon, ſlide the ſight vane H lower til the ſpot and horizon come together, and the obſervation at that time i made.

Fourthly. To the degrees between D and F add thoſe between C an H, their ſum gives the zenith diſtance: But the degrees between B and f added to thoſe between F and E, ſhews the altitude. Plate XI. Fig. 9.

For the line HA is horizontal; therefore the arc *f* BH gives the heigh of the ſun above the horizon: But *f* BH = FE + BH.

Alſo, The arc *d f* C is 90°, and zen. diſt. = comp. of altitude.

Therefore the arc *d f* + arc HC, are together the comp. of arc *f* H.

But *d f* = DF; therefore DF + HC = zenith diſtance.

1084. Now to find the latitude, the *meridian* altitude, or zenith di ſtance of the ſun is wanted: Therefore begin ſome time before noon and having taken an obſervation as before directed, wait a minute o two and obſerve again; and if the ſea appears thro' the horizon vane, th ſun has got higher, therefore ſlide the ſight vane lower till the ſolar ſpo and horizon coincide; and thus continue, until the ſky appearing inſtea of the ſea, ſhews the ſun has paſt the meridian; therefore let the van ſtand as at the laſt alteration, and add the degrees in the greater arc t the degrees and minutes in the leſſer, their ſum gives the meridiona zenith diſtance.

If inſtead of the bright ſolar ſpot, the upper border of the ſhade is mad to cut the horizon line, at the time the horizon is abreaſt that line then the ſum of the arcs gives the zenith diſtance of the ſun's uppe edge or limb, to which add 16 minutes, and the ſum is the diſtance o the ſun's centre from the zenith when he is upon the meridian. *Bu in moſt quadrants there are on the back of the greater arch a ſcale of de grees, where the ſun's ſemidiameter is allowed for.

---

* For in Pl. XI. Fig. 10. if AB repreſents the ſun whoſe centre is C, and its rays paſ over the top of an upright wall DE: Then it is evident the ray C *c* only, gives th true alt. HC, or zenith diſtance ZC: Alſo, that the ſun muſt deſcend for the ray A *a* to come to C *c*, and aſcend for the ray B *b* to come to C *c*: Therefore th ſun's ſemidiameter muſt be added in zen. diſtances, and ſubtracted in altitudes.

1085. One great objection againſt this inſtrument, is the trouble and ime loſt in ſliding the ſight vane up or down, which cannot be conveniently done without taking the quadrant from the eye, whereby an opportunity is ſometimes loſt of making the obſervation: But this defect is eaſily removed by having a long index or ruler fitted to the quadrant; one end moving round the centre to which the horizon vane is fixed, and having the ſight vane fixed to the other end. By this contrivance he ſight vane may be readily raiſed higher, or lowered, by the motion of the index about its centre, which may be done without taking the nſtrument from the eye.

1086. There is another inſtrument called a FORE STAFF, or CROSS STAFF, that has been a long time in uſe for taking the altitudes of celeſtial objects, particularly the ſtars. With this inſtrument, the obſerver holds one end of the ſtaff, which is a three feet rod, cloſe to one ſide of his eye, and ſlides a tranſum or croſs piece, which is in an upright poſition, along the ſtaff till one end of the croſs cuts the ſtar, and the other end at the ſame time cuts the horizon; then the diviſion of the ſtaff, which the croſs ſtands againſt, gives the altitude.

But the great trouble in the uſe of this inſtrument, joined to other inconveniencies attending it, make it now of little note, eſpecially ſince he uſe of a lately invented inſtrument is become more general; which far ſurpaſſes all others, for the taking of altitudes or zenith diſtances of celeſtial objects at ſea, not only for the accuracy with which it ſhews the altitude, but alſo for the readineſs and eaſe with which they are taken; whoſe deſcription and uſe here follows.

1087. *The deſcription and uſe of* HADLEY'S QUADRANT. Pl. XI. Fig. 11.

This inſtrument conſiſts of the following particulars.

I. An octant, or $\frac{1}{8}$ part of a circle, ABC.
II. The index D.
III. The ſpeculum E.
IV. Two horizon glaſſes, F and G.
V. Two ſcreens, K, K.
VI. Two ſight vanes, H, I.

I. *Of the Octant.*

The octant conſiſts of the two radius's or limbs AB, AC; the arch BC; alſo of the two braces L, M, which are to ſtrengthen and prevent it from warping. The arch contains only the eighth part of the circumference of a circle, or 45 degrees, but is divided into 90 primary diviſions, each of which ſtands for degrees, and are numbered 0, 10, 20, 30, &c. to 90, beginning at each end of the arch for the convenience of numbering both ways, either for altitudes or zenith diſtances. Every degree is ſubdivided into one or two minutes, either by the method of diagonals, or by (another which is much better, and called the) *Vernier's* diviſion, or ſcale.

II. *Of the Index.*

The index D is a flat rod or bar, moveable round the centre of the inſtrument; that part of the index which ſlides over the graduated arch

BC, has either a ſharp edge to cut the diagonal diviſions; or has Vernier's ſcale on it.

From the bottom of the index turns up a piece of braſs with a ſcrew in it, ſerving to faſten the index againſt any diviſion.

III. *Of the Speculum.*

This is a piece of flat glaſs, quickſilvered on one ſide (like common looking glaſs), and ſet in a braſs box perpendicular to the plane of th inſtrument, againſt whoſe centre ſtands the middle of the glaſs, its ſurface coinciding with the middle line of the index. Now as the index ſlides along the arch, the poſition of the ſpeculum is altered, it being fixed to the index.

The uſe of the ſpeculum, is to receive the rays from the object obſerved, and reflect them on the horizon glaſſes.

IV. *Of the Horizon glaſſes.*

Theſe are ſmall pieces of looking glaſs placed on one of the limbs with their faces turned obliquely to the ſpeculum, from whence they receive the reflexed rays of obſerved objects.

The glaſs F has only its lower part quickſilvered, and ſet in braſs work, the upper part being left tranſparent to ſee the horizon thro' it.

In the middle of the glaſs G is a tranſparent ſlit, thro' which the horizon is to be ſeen.

Both of theſe glaſſes are ſo mounted as to have their poſitions varied ſhould the wood work of the inſtrument be warped.

V. *Of the Screens.*

Theſe are two pieces of coloured glaſs ſet in frames, and are to prevent the ſtrength of the ſun's rays from hurting the eye during the time of obſervation: When they are uſed with the glaſs F, they are to be where the figure ſhews them; but when uſed with the glaſs G, they are to be ſet at the hole *r* above G.

VI. *Of the Sight vanes.*

That at H is uſed with the glaſs G in back obſervations: And the ſight vane I, which has two holes, is uſed with the glaſs F in fore obſervations.

For with this inſtrument an obſervation may be made with the face either turned from the object, and called a back obſervation; or with the face turned towards the object, and called a fore obſervation.

1088. *To take the ſun's altitude with Hadley's quadrant.*

Put the ſtem of the ſcreens K, K, into the hole *r*, and according to the faintneſs or ſtrength of the ſun's rays, let neither, or either, or both, of the frames of theſe glaſſes be turned cloſe to the face of the limb; turn your back to the ſun; with your left hand hold the inſtrument by the braces L, M, ſo that it be in a vertical poſition, and the arch downward; put the eye cloſe to the hole in the vane H; look for the horizon thro'

thro' the tranſparent ſlit in the horizon glaſs G; with the right hand move the index D until the reflected image of the ſun is ſeen in the quickſilvered part of the glaſs G, and in a line with the horizon; ſwing your body to and fro, and if the ſun's image be obſerved to bruſh the horizon, then is the obſervation well made, and the degrees, reckoned from that end of the arch fartheſt from your body, will give the ſun's altitude at that time; ſubtracting 16 minutes if the ſun's lower edge be uſed; and adding 16 minutes to the altitude when it is taken by the upper edge: But if taken by the centre, there is no need of this correction.

1089. *To take the altitude of a ſtar by Hadley's quadrant.*

Thro' the vane H, and the tranſparent ſlit in the glaſs G, look directly at the ſtar; at the ſame time move the index till the image of the horizon behind you, being reflected by the great ſpeculum, is ſeen in the quickſilvered part of G, and meets the ſtar; and the index will then ſhew the degrees of altitude.

Theſe methods are both by the back obſervation; but the altitude of any celeſtial object may be taken by a fore obſervation (which is moſtly practiſed if the horizon towards the object be conſpicuous): For which, and the methods of rectifying the inſtrument, the reader is referred to the little book generally given with theſe quadrants at the ſhops where they are ſold.

The directions already given for the taking of altitudes at ſea would be ſufficient, were it not for two corrections neceſſary to be made, before the altitude can be accurately aſſigned: The firſt of theſe ariſes on account of the obſerver's eye being raiſed above the plane of the horizon; and the ſecond on account of the refraction occaſioned in ſmall altitudes by the hazineſs of the atmoſphere.

1090. *Of the correction for the horizontal dips.* Pl. XI. Fig. 12.

The eye being raiſed above the level of the ſea, obſerves an horizon below the level of the true one.

Thus let *a* S *f* be the ſurface of the ſea, E S the height of the eye above that ſurface, and A F the obſerver's horizon: Then the eye looking along E *a* for the horizon, it dipping below the true one, by the arc A *a*, the apparent altitude *a* B of an object B muſt evidently be leſſened by the arc A *a*: But if the obſerver has his back towards the object B; then looking along the line E *f*, the apparent horizon now becoming the line *f* E *c*, and dipping below the true one by the arc F *f*, or A *c*; it is plain the apparent altitude *c* B is too little, and muſt be augmented by the arc A *c* = F *f*.

Conſequently in the fore obſervations, the altitude muſt be leſſened by the horizontal dip; and in the back obſervations the altitude muſt be increaſed by the dip; but in zenith diſtances, add the dips forwards, and ſubtract them backwards.

1091. *To compute the horizontal dips.*

Let c be the earth's centre, E the eye, and the tangent E*f* meeting th ſurface in *f*, where the ſky and water ſeem to meet; then c*f*E is a triangle right angled at *f*, wherein are known c*f* = cs = 20899059 feet, th earth's ſemidiameter; and CE = (cs + SE) the height of the eye adde to the earth's radius: Then as CE : Rad : : c*f* : ſin. ∠CE*f*, who complement is the ∠FE*f*, the dip ſought.

And in this manner was the table here annexed calculated to the different elevations of the eye therein ſpecified.

1092. *Of the correction cauſed by refraction.*

The hazineſs, or vapours, in the atmoſphere cauſes the ſun and ſtai to appear higher, or with greater altitudes than what they really have Theſe refractions have been collected by eminent aſtronomers; and a far as obſervations at ſea may be affected by the atmoſphere, the refractions are inſerted in the annexed table. Hence it is evident the apparen altitude is to be leſſened by the refraction; but it muſt be added to th zenith diſtance.

And becauſe the corrections of altitude may appear at ſight, therefor the horizontal dips, and the refractions, are both exhibited in the following table.

1093. *A* TABLE, *ſhewing the corrections to be made to altitud taken at ſea, both on account of the height of the eye above the horizon, and of the refraction of the atmoſphere.*

Heights of the eye	Corrections	Altitud. obſerv'd	Corrections	Altitud. obſerv'd	Corrections
Feet	Minutes	Degrees	Minutes	Degrees	Minutes
5	2	1	23	12	4
10	3	2	17½	15	3½
15	4	3	14	20	2½
20	5	4	11	25	2
25	5½	5	9	30	1½
30	6	6	8	35	1⅓
35	6½	7	7	40	1
40	7	8	6	50	0¾
45	7½	9	5½	60	0½
50	8	10	5	70	0⅓

To have the ſun's or ſtar's altitude, or zenith diſtance, as truly as th inſtruments will take them, the obſervation muſt always be corrected b theſe numbers, whether it is made by Davis's or Hadley's quadrants, c by any other inſtrument.

Genera

General rules for uſing the Table of corrections.

1094. *In the fore obſervations.*

Add the ſum of the corrections to the obſerved zenith diſtance, for the rue zenith diſtance.

Or, Take the ſum of the corrections from the obſerved altitude, for he true altitude.

1095. *In the back obſervations.*

For altitudes, add the dips and ſubtract the refractions.

And for zenith diſtances, ſubtract the dips and add the refractions.

Alſo, when the edge of the ſun is obſerved by Hadley's quadrant.

096. *In the fore obſervation.*

To the obſerved altitude add 16 minutes, if the ſun's lower edge is rought to the horizon: Or, ſubtract 16 minutes, when the horizon nd upper edge coincide.

097. *In the back obſervation.*

To the obſerved altitude add 16 minutes, if the ſun's apparent upper dge comes to the horizon: Or, ſubtract 16 minutes, if its lower edge s brought in a line with the horizon.

Exam. I. *By a back obſervation, the altitude of the ſun's lower edge was ound by Hadley's quadrant to be* 25° 12′; *the eye being* 30 *feet above the orizon: Required the correct altitude?*

The dip on 30 feet high is 6 min.; and the refrac. on 25° is 2 min.

Alt. ☉ lower edge	25° 12′	Ap. alt. ☉	24° 56′	From	25° 02′
Subtract ſemidiam.	0 16	Add dip	0 06	Take refrac.	0 02
App. alt. ☉ centre	24 56	Sum	25 02	Cor. alt.	25 00

And in like manner muſt all the obſervations of the ſun's altitude be orrected, before the latitude is found.

Exam. II. *By a fore obſervation, the altitude of the ſun's lower edge vas found by Hadley's quadrant to be* 30° 20′; *the eye being* 20 *feet above he horizon: Required the correct altitude?*

Alt. ☉ lower edge	30° 20′	Ap. alt. ☉	30° 36′	From	30° 31′
Add ſemidiam.	0 16	Take dip	0 05	Take refrac.	0 01
App. alt. ☉ centre	30 36	Remains	30 31	Cor. alt.	30 30

1098. *To make an artificial Horizon.*

One great inconvenience that mariners have to ſtruggle with at ſea is the frequent want of an horizon: For tho' the atmoſphere may, a the height of 10 or 12 degrees and upwards, be clear enough to give view of the ſun or other objects, yet all below that height is oft ſo haz as to hinder a diſtinct ſight of the horizon; and conſequently an obſervation made at ſuch a time cannot have the correctneſs wiſhed for But this defect is quite removed by a kind of horizontal ſpeculum invented by Mr. *Serſon*, who was loſt with the *Victory* man of war, wherein he was ſent to make trial of his machine.

The principle whereon the ingenious author founded this inſtrument was derived from the conſideration of a top while ſpinning; for he obſerved, that the top had a very conſiderable degree of ſteadineſs in, an force to acquire an upright motion; whether the body which ſupporte it was in motion or at reſt, in an horizontal or an inclined ſituation He therefore judged, that if a circular machine, whoſe upper ſurface wa a flat poliſhed ſpeculum, was to have a ſwift circular motion communicated to it, that ſpeculum, by acquiring an horizontal ſituation, woul ſhew all objects which it reflected, as much below the horizon, as the really are above it, in the ſame manner as in a common looking glaſs conſequently if the image of the ſun, as ſeen reflected from the ſpeculum, was made to coincide with the ſun's image, ſeen in a Hadley' quadrant; the angle given by the quadrant would in all caſes be the double of the real altitude. Mr. *Serſon* alſo found, that to confine the ſpeculum to one place while it was ſpinning, it was neceſſary to let th point-run in a hollow cup; for the horizontality of the ſpeculum woul not be altered, whatever poſition might be given to the cup, provide it touched the *Top* only at the point it ſpun on.

1099. This curious and uſeful inſtrument, as it is now improved by Mr *John Smeaton*, F. R. S. conſiſts in a well-poliſhed metal ſpeculum of abou $3\frac{1}{2}$ inches in diameter, incloſed within a circular rim of braſs; ſo fitted that the centre of gravity of the whole ſhall fall near the point whereon it ſpins; that is, the end of a ſteel axis running thro' the centre o the ſpeculum, above which it finiſhes in a ſquare, for the convenienc of fitting a roller to it, when it is to be ſet a going by the means of piece of tape wound round the roller. The cup in which it ſpins is mad of poliſhed agate, flint, or other hard ſubſtance, and is placed on a ſmal pillar, which is fixed to the bottom of a box, whoſe pyramidal cove is compoſed of glaſs planes; whereby an obſervation can be made o the ſpeculum as well covered as uncovered, and thereby it will be prevented from tarniſhing by the moiſt air or ſpray of the ſea.

1100. When the *Top* is to be uſed in a meridian obſervation, it is convenient to know about what time it is proper to ſet it up; this may be had near enough by taking the ſun's bearing from the meridian with a azimuth compaſs, allowing for the variation; and if it has about 5 degree

ſe

to run before it culminates, it is time to ſpin the *Top*, which will generally run 12 or 15 minutes fit for obſervation: But if it is likely to go down, or ſpin too weak, before the obſervation can be finiſhed, the tape ſhould in the mean time be got ready wound about the roller, that the *top* may be ſet up again without loſs of time; and if the box be held ſteady upon ſomething nearly level when the tape is drawn away, the ſpeculum will be fit for obſervation commonly in leſs than two minutes.

As ſoon as the *Top* is ſet up, put on the glaſs roof if neceſſary; let an aſſiſtant hold the box as ſteady and level as he can, and in ſuch a poſition as the obſerver may look directly thro' the glaſs roof: Then let the obſerver place himſelf as near the box as he can conveniently, and look down on the ſun's image in the horizontal ſpeculum, and bring the ſun's image ſeen in the quadrant to agree with it, ſo that their centres coincide, and the quadrant will give the double altitude, without any allowance for the height of the ſhip, or the ſun's ſemidiameter. And altho' there may appear in the horizontal image a kind of trembling, yet when the centres of the ſolar images are brought to coincide, the obſervation may be taken as truly as if there was no ſuch trembling.

1101. When the ſun is above 45 degrees high, the obſerver muſt look thro' that ſight of the quadrant which is uſed for a back obſervation: But he muſt look down on the horizontal image, or that in the top, as if it was the back horizon; and then making the ſolar images to agree, the quadrant, according as it is numbered, will give the double altitude, or double zenith diſtance.

As this latter obſervation is ſometimes found at firſt more difficult to make than the former, the obſerver would do well to exerciſe himſelf therein in good weather, when he has an opportunity of comparing his obſervations with thoſe taken from the horizon properly corrected.

Theſe *ſpeculum tops* are as uſeful by night as by day; for as the images of the ſmalleſt ſtars may be ſeen in the ſpeculum, conſequently any object that can be ſeen reflected from the glaſſes of the quadrant, may be obſerved by the *top*; and theſe are all the ſtars of the firſt magnitude, the planets Venus, Mars, Jupiter, Saturn, and the moon: So that by having the declinations of theſe bodies in an Ephemeris, they may be uſed in obſervations as well as the ſun.

As the great diſtreſſes to which ſhips are ſometimes drove in ſeveral parts of the world for want of an horizon to obſerve by, are by this moſt ingenious contrivance quite removed. It is to be hoped, that when the uſe of this inſtrument is more generally known, few ſhips will be without one, altho' the expence ſhould amount to five guineas.

SECTION

SECTION VIII.

1102. *To find the Latitude by obſervation.*

Find the meridian altitude or zenith diſtance of the ſun or ſtar by article 1084 or 1088.

Correct the altitude or zen. diſt. as ſhewn in arts. 1094, 95, 96, 97.

Seek the ſun's or ſtar's declination in the Tables at art. 1052, 1054 obſerving to correct the ſun's decl. for places more than 12° to the E. o W. of London, as at art. 963.

In latitudes near the poles, when the ſun's declination exceeds th co-latitude, the ſun then does not ſet; and therefore two altitudes ma be taken on the meridian; the leaſt of which is called the altitude below the pole: And the ſame may be underſtood of any other celeſtia object, which does not ſet.

Let the declination and the altitude, or zenith diſtance, be alway named either north or ſouth, according to the ſeaſon of the year, and th ſituation of the object; and when it ſo happens that they are of no magnitude, they may then be named either north or ſouth at pleaſure.

Theſe remarks being premiſed, all the varieties of working an obſervation for the latitude are contained in the ſolution to the following problem.

PROBLEM.

The declination of the ſun or a ſtar, and alſo its meridian altitude, or zenith diſtance being known; to find the latitude of the place of obſervation.

WHEN THE OBJECT RISES AND SETS.

1103. CASE I. *If the zen. diſt. and decl. have the ſame name.*

RULE. Their difference ſhews the latitude required.

Like the declination, when it is greater than the zenith diſtance: But unlike, when it is leſs than the zenith diſtance.

1104. CASE II. *If the zen. diſt. and decl. have contrary names.*

RULE. Their ſum ſhews the latitude required.

And is always like the declination.

When altitudes are given, take them from 90° for zenith diſtances.

1105. WHEN THE OBJECT DOES NOT SET.

If the greateſt meridian altitude or zenith diſtance can be taken, the preceding rules will ſerve: But when the leaſt, or that below the pole, can only be taken. Then

RULE. To the meridian altitude below the pole, add the co-declination, the ſum ſhews the latitude, of the ſame name with the declination.

The demonſtrations of theſe rules will be ſhewn after the examples.

Exam. I. *The ſun's meridional zenith diſtance was obſerved to be* 48° 20′ *ſoutherly, when he entered the ſign Aries: Required the lat. of the place?*

The zenith diſtance	48° 20′ S.
Declination	00 00 S.
Latitude ſought	48 20 N. (1103)

Exam. III. *Being at ſea, the ſun was obſerved in the zenith, when his leclination was* 22° 10′ *N.: What s the latitude of that place?*

The zenith diſtance	00° 00′ N.
Declination	22 10 N.
Lat. ſought	22 10 N. (1103)

Exam. V. *The ſun was obſerved o be* 47° 25′ *diſtant from the zenith n the ſouth, when his declination was* 4° 18′ *S.: What is the lat. of the lace of obſervation?*

The zenith diſtance	47° 25′ S.
Declination	14 18 S.
Lat. ſought	33 07 N. (1103)

Exam. VII. *December* 12*th*, 1753, *he ſun's meridian zenith diſtance was bſerved to be* 8° 25′ *S.: Required the titude of the place?*

The zenith diſtance	8° 25′ S.
Declination	23 07 S.
Lat. ſought	14 42 S. (1103)

Exam. IX. *Auguſt* 25*th*, 1753, *he ſun's meridian zenith diſtance was bſerved to be* 32° 57′ *S.: What is he latitude of the place?*

The zenith diſtance	32° 57′ S.
Declination	10 51 N.
Lat. ſought	43 48 N. (1104)

Exam. II. *When the ſun entered the ſign Libra, his meridian altitude was obſerved to be* 53° 32′ *in the north: What is the latitude of that place?*

The co-alt. or zen. dif.	36° 28′ N.
Declination	00 00 S.
Lat. ſought	36 28 S. (1104)

Exam. IV. *The ſun's meridian zenith diſtance was obſerved* 21° 08′ *S., when his decl. was the ſame: Required the latitude of the place of obſervation?*

The zenith diſtance	21° 08′ S.
Declination	21 08 S.
Lat. ſought	00 00 S. (1103)

Exam. VI. *The ſun's meridian altitude was obſerved to be* 54° 27′ *north, when his declination was* 19° 57′ *north: Required the latitude of the place?*

The co-alt. or zen. dif.	35° 33′ N.
Declination	19 57 N.
Lat. ſought	15 36 S. (1103)

Exam. VIII. *June* 12*th*, 1754, *obſerved the ſun's meridian altitude to be* 79° 23′ *N.: What is the latitude of the place of obſervation?*

The co-alt. or zen. dif.	10° 37′ N.
Declination	23 13 N.
Lat. ſought	12 36 N. (1103)

Exam. X. *Suppoſe the meridian altitude of the ſun was obſerved to be* 48° 14′ *N., when his declination was* 17° 38′ *S.: Req. the lat. of that place?*

The co-alt. or zen. dif.	41° 46′ N.
Declination	17 38 S.
Lat. ſought	59 24 S. (1104)

In the ſame manner, the latitude may be found by obſervations of the titude or zenith diſtance of any known ſtar, or ſuch whoſe declina-on is known; for which ſee the table at art. 1054.

Exam. XI. *Obſerved the meridian zenith diſtance of Sirius to be 36° 25′ N.: Required the latitude of the place of obſervation?*

The zenith diſtance	36° 25′ N.
Declination	16 21 S.
Lat. ſought	52 46 S.

Exam. XII. *The meridian altitude of the ſtar Arcturus was obſerved to be 68° 39′ S.: What is the latitude of the place of obſervation?*

The co-alt. or zen. diſt.	21° 21′ S.
Declination	20 38 N.
Lat. ſought	41 59 N.

Exam. XIII. *June 12th, 1753, the ſun was obſerved on the meridian, when his altitude below the pole was 8° 45′ N.: What is the latitude of the place of obſervation?*

The altitude	8° 45′ N.
Co-declin.	66 50 N.
Lat. ſought	75 35 N.

Exam. XIV. *December 18th, 1754, the ſun's meridian altitude below the pole was found to be 10° 25′ ſouth: Required the latitude of the place of obſervation?*

The altitude	10° 25′ S.
Co-declination	66 34 S.
Latitude ſought	76 59 S.

1106. *Demonſtration of the preceding rules.*

See Plate XI. Figures 13, 14, 15.

Let the circle HZRN repreſent the meridian of the place, HR the horizon, and Z its zenith or pole: Alſo let PS repreſent the axis, P being the north, and S the ſouth pole; the line EQ the equator, ☉ the place of the ſun, the arc Z☉ the zenith diſtance, and E☉ the declination.

Now the latitude is expreſſed either by the height of the pole above the horizon, or by the diſtance of the equator from the zenith; conſequently the arc RP = HS, or the arc ZE, being known, will give the latitude.

But the arc ZE is ever equal to the ſum of the arcs Z☉ and E☉, when of contrary names; or to their difference when of the ſame name.

When the object does not ſet, then its leaſt altitude R☉ added to the arc P☉, or co-declination, gives RP, the height of the pole above the horizon, or the latitude ſought: And the ſame may be underſtood, was the leaſt altitude above the ſouth point of the horizon.

Hence it will be eaſy to conſtruct any of theſe caſes. Thus:

Set the zen. diſt. from Z, to the left if ſouth, but to the right if north; and this gives ☉ the place of the ſun.

Set the decl. from ☉, to the right if ſouth, but to the left if north; and this gives E the place of the equator.

Then drawing the diam. EQ, and the diam. PS at right angles to EQ; the latitude will be north or ſouth, according as P or S falls above the horizon.

ASTRONOMY Pl. XI.

Fig. 1. Pa. 484.

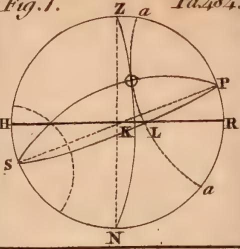


Fig. 2. Pa. 484.

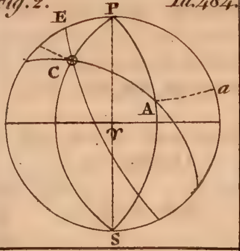


Fig. 3. Pa. 485.

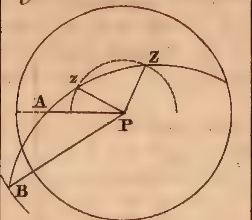


Fig. 4. Pa. 485.

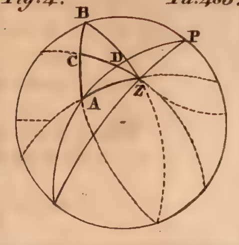


Fig. 5. Pa. 486.

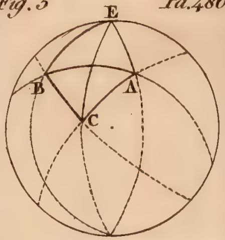


Fig. 6. Pa. 487.

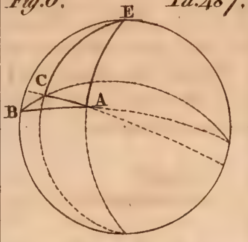


Fig. 7. Pa. 487.

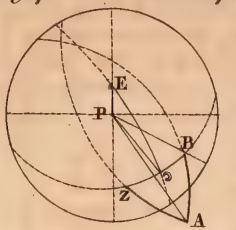


Fig. 8. Pa. 514.

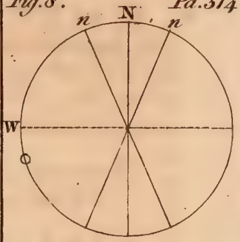


Fig. 9. Pa. 517.

Fig. 10. Pa. 518.

Fig. 11. Pa. 519.

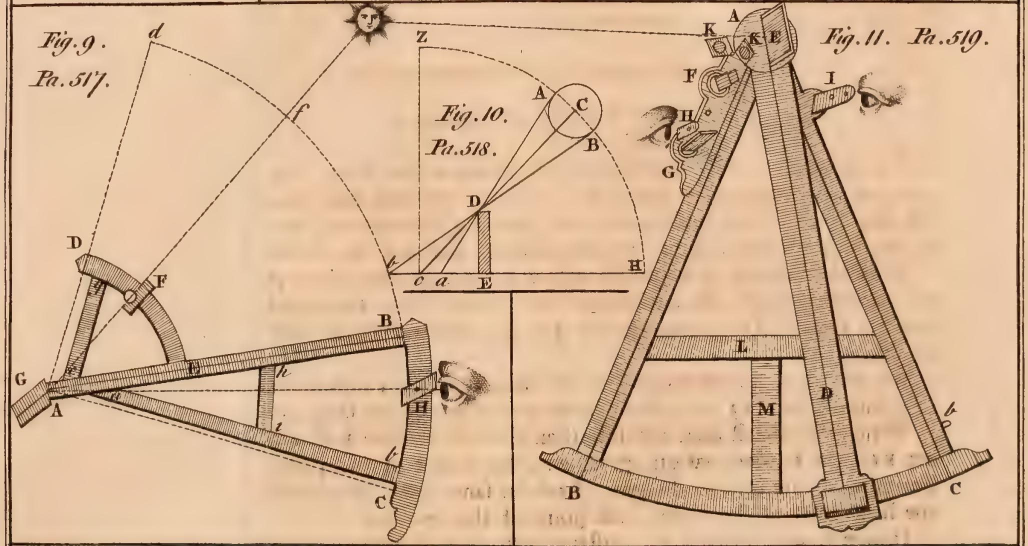


Fig. 12. Pa. 521.

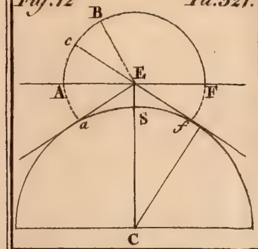


Fig. 13. Pa. 528.

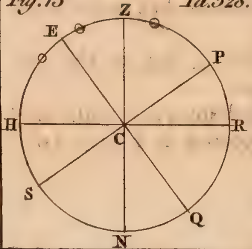


Fig. 14. Pa. 528.

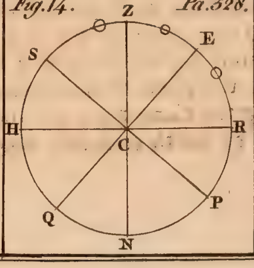
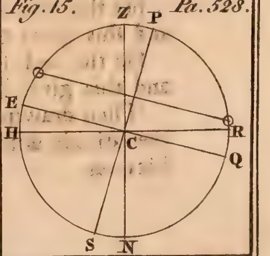


Fig. 15. Pa. 528.



T. Jefferys sculp.

Page 528.

SECTION IX.

Of a Ship's Reckoning.

1106. A SHIP'S RECKONING is that account, whereby at any time it may be known where the ſhip is, and on what courſe or courſes ſhe is to ſteer to gain her port.

DEAD RECKONING, is that account deduced from the occurrences wrote on the log-board.

The LOG-BOARD is a painted black board, whereon is wrote in chalk whatever is thought worthy of note from day to day; and for a proper diſpoſition of ſuch notes, the board is divided into five columns: The left hand one contains the 24 hours from the noon of one day to the noon of the next; in the 2d and 3d columns are the knots and fathoms the ſhip is found to run per hour, ſet againſt the hours when the log was hove; the 4th column contains the courſes the ſhip ſteers; and in the 5th, or right hand column, is wrote the winds, the alteration of the ſails, the buſineſs doing aboard, and what other remarks the officer of the watch thinks proper to inſert: For it ſhould be obſerved, that it is uſual to divide a ſhip's company into two parts, called the ſtarboard and larboard watches, who alternately do the duty of the ſhip for four hours and four hours.

1107. The LOG-BOOK is a book ruled like the log-board, in order to contain the daily copies of the remarks wrote on the log-board, which is the only authentic record of the ſhip's tranſactions; and theſe are by the perſons who keep *Journals* tranſcribed every day at noon into their log-books, from whence they make the neceſſary deductions relative to the ſhip's place.

1108. But as the ſhip's motion is liable to be diſturbed from a variety of cauſes, ſuch as a continual deflection from the courſe ſet, by the ſhip's playing to the right and left round her centre of gravity, and the unequal care of the *helmſmen*; the diſtance being faulty, on account of tumbling ſeas rolling with or againſt the ſhip; the unſteadineſs of the wind; unknown currents; ſudden ſtorms, and many other impediments which ſeem impoſſible to be ſurmounted; conſequently her place, according to the dead reckoning, may be juſtly doubted, and therefore mariners try every day to find the latitude their ſhip is in by obſervations on the ſun or ſtars; and if the latitude obtained by obſervation, and that found by dead reckoning, agree, it is preſumed the ſhip's place is well determined: But if they diſagree, the account of longitude muſt be corrected; and for the latitude, that found by obſervation is always to be depended on.

1109. *Various methods of correcting the Reckoning of longitude.*

Conſider whether the difference may not have been occaſioned by a current, and if it is poſſible, try it (by art. 706); or make ſuch an eſtimate of its ſetting and drift as may be judged reaſonable: Then with the ſetting and drift, as a courſe and diſtance, find the diff. lat. and diff. long., with which increaſe or diminiſh the dead reckoning; and if the latitude, thus corrected, agrees with the latitude by obſervation, then the longitude thus corrected may be ſafely taken as true, and ſo the ſhip's place determined.

EXAM. *Suppoſe a ſhip in* 24 *hours finds by her dead reckoning ſhe ha made* 96 *miles of diff. lat. N., and* 38 *miles of departure weſt; but by obſervation, finds her difference of latitude is* 112, *and on trial finds a current, which in* 24 *hours make* 16 *miles of diff. lat. N., and* 10 *miles of dep. E.. Required the ſhip's departure?*

Diff. lat. by account	96 m. N.	Departure by account	38 m. W
Diff. lat. by current	16 m. N.	Departure by current	10 m. E.
True diff. lat.	112 m. N.	True departure	28 m. W

Here the dead reckoning corrected by the current gives the diff. lat 112 miles, which is the ſame as found by obſervation; therefore th departure 28 is taken as the true one.

1110. The error in the dead reckoning is uſually attributed to unknown currents: For by various cauſes, yet indetermined, there ar many counter-motions of the water in the open ſeas, as well as thoſe obſerved near the ſhores where the motions may be tolerably well accounte for. Some of the obſerved currents in the great ſeas may perhaps be owing to the tide's following the moon, and to the libratory motion th waters may have thereby; and the unſettled ſetting and drift of theſ currents may poſſibly depend on the change in the moon's declination However, it is well known from obſervations that the trade winds occaſion a conſiderable current within their limits, particularly within the Torrid zone, where the motion is perpetually towards the weſt, at the rat of about 8 or 10 miles a day: But at the extremities of the trade winds or near the latitudes of 30 degrees north and ſouth, it is likely that th currents are compounded of the ſaid weſtern motion, and of one toward the equator (by obſ. 2d. art. 607): Therefore all ſhips ſailing withi theſe limits ſhould allow a courſe each day for this current.

1111. If when all currents have been allowed for, there ſhould ſtil be a difference between the obſerved latitude and that given by account then a farther correction muſt be made.

The buſineſs of correcting a ſea reckoning is a very precarious operation, and at beſt is little more than gueſſing; for by ought that appears the ſhip may be either to the eaſtward or weſtward of the point wherei the reckoning places her, and the mariner not be able to pronounce wit certainty whether: However, the following methods are uſually taken.

If the difference of latitude is much more than the departure, or th direct courſe has been within three points of the meridian; then it i moſt likely the error is in the diſtance.

And if the departure is much greater than the diff. lat., or the direct courſe is within three points of the parallel, or more than five points fro the meridian, the error may be aſcribed to the courſe.

But if the courſes are in general near the middle of the quadrant, th error may be either in the courſe, or in the diſtance, or in both.

For, to cauſe an alteration in the diff. lat., the firſt of theſe caſes requires a greater error in the courſe than can well be ſuppoſed to have been committed; in the ſecond caſe, the diſtances muſt be ſo faulty as would ſcarce eſcape obſervation; and in the laſt, it is often doubtful whether to attribute the error to the courſe or diſtance; but it is uſually corrected in both.

1112. First Method.

When, by the dead reckoning, the diff. lat. is more than once and a half the departure: Or, which is the ſame, when the courſe is leſs than three points:

To the diff. lat. and the departure by account, find the courſe.
With this courſe, and the diff. lat. by obſervation, find a new depart.
With the new depart., and the co-mid. lat., find the diff. long.

Exam. *Yeſterday noon we were in lat.* 39° 18′ *N., and by an obſervation, are this day noon in lat.* 37° 48′ *N.; our dead reckoning gives* 106 *miles of ſouthing, and* 64 *miles of eaſting: Required the ſhip's true difference of lon.?*

By the Traverse table.

The diff. lat. 106, and the dep. 64, gives the courſe $2\frac{3}{4}$ points.
The courſe $2\frac{3}{4}$ points, and the diff. lat. by obſerv. 90, gives a dep. 54.
The co-mid. lat. 51° 27′, and true dep. 54, gives the diff. long. 69.

1113. Second Method.

When, by the dead reckoning, the departure is more than once and a half the diff. lat.: Or, the courſe is more than five points.

With the diff. lat. and dep. by account, find the diſtance.
With this diſtance, and the diff. lat. by obſerv. find the true depart.
With the co-mid. lat. and true dep. find the diff. longitude.

Exam. *Yeſterday noon we were in lat.* 48° 52′ *N., and were to day at noon in lat.* 50° 18′ *N.; our dead reckoning ſhews we have made* 68 *miles of northing and* 112 *miles of weſting: Required the true difference of longitude the ſhip has made?*

By the Traverse table.

The diff. lat. 68 and dep. 112, gives 132 for the diſtance.
The diſt. 132, and diff. lat. by obſerv. 86, gives the true depart. 100.
The co-mid. lat. 40° 25′, and true dep. 100, gives 155 miles for diff. longitude.

1114. Third Method.

When the diff. lat. and departure by account are nearly equal, or the direct courſe has been between three and five points of the meridian.

To the diff. lat. and depart. by account, find the diſtance.
With this diſt. and diff. lat. by obſervation, find another departure.
Take the half ſum of the two departures for the true one.
With the co-mid. lat. and true dep. find the diff. longitude.

Exam. *Theſe laſt* 24 *hours we have made* 84 *miles of northing, and* 76 *of eaſting; we were yeſterday noon in lat.* 52° 40′ *N., and are this noon in lat.* 54° 22′ *N.: What diff. longitude has the ſhip made?*

By the Traverse table.

To the diff. lat. 84 and dep. 76, the diſtance is 113 miles.
With the diſt. 113 and diff. lat. by obſerv. 102, find a dep. 47,7.
The ſum of the two departures 76 and 47,7 is 123,7, its half is 61,8
To the co-mid. lat. 36° 29′ and true dep. 61,8, the diff. long. is 103.

1115. The difficulty of finding the longitude at ſea has inclined man perſons to attempt the ſolution of this moſt uſeful problem: Some, wit no other view than the great advantage which the art of navigatio would derive from their labours; others, and by much the greateſt number, who have exhibited their thoughts on this ſubject, were viſionar whimſical men, only lured by the hopes of the appointed reward: Bu Dr. Halley having collected a great multitude of obſervations made o the variation of the needle in many parts of the world, he by the help o the latitude and longitude of the places of thoſe obſervations, was enabled to draw on a Mercator chart certain lines, ſhewing the variatio of the compaſs in all thoſe places over which they paſſed at the time h publiſhed, in the year 1700; and conſequently the longitude of any o thoſe places could be found by the chart, having its latitude and the variation of the needle in that place given.

1116. Fourth Method.

To find the longitude at ſea by the variation chart.

Find the variation of the compaſs. For which ſee art. 1076.

Draw a parallel of latitude on the chart thro' the lat. found by obſervation.

And the point where it cuts the curved line, whoſe variation is th ſame with that obſerved, will be the ſhip's place.

Exam. *A ſhip finds by a good obſervation that ſhe is in the lat. of* 18 20′ *N.*; *and that the variation of the compaſs is* 4° *weſt: Required th ſhip's place?*

Take from the graduated meridian the diſtance between the equato and the lat. of 18° 20′ N.: Lay a ruler along the equator, and ſlide on point of the compaſſes along its edge till the other point cuts the curv of 4° weſt variation, and the interſection gives the ſhip's place, whoſ longitude will be found to be about 27° 10′ weſt from London.

1117. There are two conſiderable inconveniences which attend thi method.

Firſt. That wherever the variation lines run eaſt or weſt, or nearly ſo this way of finding the longitude becomes imperfect: But among all th trading parts of the world, this imperfection is at preſent found chiefl on the weſt coaſts of Europe between the latitudes of 45° and 53°; on th eaſtern ſhores of North America, and in ſome parts of the weſtern ocea and Hudſon's bay, lying between the ſaid ſhores; therefore, for the othe parts of the world, a variation chart may be eſteemed as of the greate uſe.

1118. But the variation curves, even where they run eaſt and weſt may be ſometimes applied to good uſe in correcting the latitude, whe meridia meridian obſervations cannot be had, as it frequently happens on the northern coaſts of America, in the weſtern ocean, and about Newfoundland: For if the variation can be obtained correctly, then the eaſt and weſt curve anſwering to that variation on the chart will ſhew the latitude.

Secondly. As the deflection of the magnetical meridian from the true one is ſubject to continual alteration; therefore a chart, to which the variation lines are fitted for any year, muſt in time become uſeleſs, unleſs new lines, ſhewing the ſtate of the variation at that time, be drawn on that chart: But as the change in the variation is very ſlow, therefore new variation charts being publiſhed every 10 or 12 years, will anſwer the purpoſe wanted.

In the year 1746 Mr. William Mountaine, F. R. S. and Mr. James Dodſon fitted the variation lines to Dr. Halley's chart, for the year 1744. As theſe gentlemen had collected ſeveral thouſands of obſervations to work on, they were enabled to perform this buſineſs with great correctneſs; inſomuch, that wherever their chart has been uſed it was found of very great importance, even to the ſaving a ſhip in the Indian ocean; and it is much to be wiſhed they were in more general uſe.

1119. FIFTH METHOD.

To find the longitude from celeſtial obſervations.

It was ſhewn at article 657, that the difference of longitude between two places could be determined, by knowing the difference between the times that any remarkable appearance in the heavens was ſeen in thoſe places.

For as theſe appearances conſiſt in the *appulſes*, that is, the approaches of the heavenly bodies to one another, or their paſſage by one another; and theſe appulſes when they happen, are ſeen at the ſame inſtant of abſolute time to all parts of the earth where they are viſible: Therefore by knowing the relative times of the day when ſuch appearances are ſeen in two diſtant places, the difference between thoſe times is known, and conſequently the difference of longitude between thoſe places.

There are every year publiſhed ſeveral Almanacs, or Ephemeres, wherein are noted the eclipſes of the ſun and moon, the times of the planets riſing, ſetting, and ſouthing; the eclipſes of Jupiter's ſatellites, and the times when other celeſtial appearances may be ſeen at the places for which thoſe Ephemeres are calculated: Now a mariner having one of theſe Almanacs, if he obſerves at what time any of theſe appearances happen in any part of the world he may be then in, will readily know his longitude.

1120. Among the ſatellites of Jupiter, one or more is eclipſed almoſt every night; for they diſappear either in going behind Jupiter, or in paſſing before him; and the inſtants of ſuch immerſions and emerſions may be ſeen by a refracting teleſcope of about 8 or 9 feet long, or by a reflecting one of about 9 inches focal length. The reflecting teleſcope is much more commodious at ſea, on account of its ſhortneſs; but the metals are very ſubject to be tarniſhed by the moiſt air.

1121. To determine the longitude of any place from celeſtial obſervations, it is neceſſary that the time of the day be well known in that place where the obſervation is made; and among the various metho propoſed for this purpoſe, none ſeems more fit to be practiſed at ſea tha the method by *equal altitudes*; for no regular deductions can be made without knowing the preciſe time of noon. Now as clocks and watches undergo conſiderable alterations from the motion of a ſhip and the chang of the climate, they ought to be carefully examined, and their gain o loſs per day aſcertained whenever they are to be uſed in the correcting o the longitude; and this need not be done very often, only at ſuch time when the ſhip may be ſuppoſed thro' ſtorms or bad weather to be conſiderably out in her dead reckoning.

At ſuch times, the ſhip lying by, let the ſun's altitude be taken at an time in the forenoon, ſet down that time and altitude: In the afternoon watch for the ſun's having the ſame altitude exactly, and note dow that time; then the half ſum of theſe two times, is the time ſhewn b the clock or watch when it was noon in that place.

As it is poſſible that an altitude, equal to one taken on the eaſtern ſid of the meridian, cannot be obſerved on the weſtern ſide, by the interpoſition of clouds; it is therefore beſt to take ſeveral in the forenoon, o on the eaſt ſide, in order to have the greater probability of ſecuring correſponding altitude on the weſtern ſide or afternoon; and if ſevera obſervations of equal altitudes can be made on both ſides of the meridian it will be beſt to take the mean time correſponding to each pair of equa altitudes; and if the means all agree, it is an evident ſign that the obſervations were well made: But ſhould they diſagree half a minute o ſo; then it is beſt to add together all the times of noon, and divide th ſum by the number of times, and the quotient may be taken for th true time of noon in that place, as ſhewn by the clock or watch.

In the taking of theſe equal altitudes of the ſun, it will be moſt convenient to have them at a diſtance from one another not exceeding 4 o 5 hours; becauſe then there will be no occaſion to correct the latte altitude by the alteration in declination during that time.

1122. The true time of noon being obtained, then the time that an planet, or other celeſtial body paſſes the meridian, may be thus known On the evening following, let one or more altitudes of the planet b taken, which ſet down with their reſpective times; and on the nex morning note down the times when that planet has the ſame altitudes The half ſum of theſe two times will be the time when the obſerve planet paſſed the meridian of that place; and if ſeveral obſervations hav been taken, find the mean of them, as before for the ſun: But if th planet obſerved be the moon, whoſe declination may be conſiderabl altered between the times of the obſervations; then let a proportiona part of her daily variation in declination be added to, or ſubtracted from the time found for her paſſing the meridian, according as the moon i receding from, or approaching to, the elevated pole.

And if there is reaſon to ſuſpect that the clock or watch gains or loſe every day; let the times of two equal altitudes of the ſun be taken nex day, and the noon thereby determined: Then the difference betwee the times of noon both days, as ſhewn by the clock or watch, will b its daily variation; and the time of the planet's paſſing the meridian muſ be increaſed or diminiſhed by a proportional part of that variation.

1123. Now by having a table or an Ephemeris, containing the times when the moon paſſes the meridian of a certain place; and by having from obſervation the time when ſhe paſſes the meridian of any other place, the difference between the longitudes of thoſe two places may be thus found.

Seek in the Ephemeris for the time of her ſouthing on the given day, and that of the following day, and take their difference; alſo take the difference between the times of the tabular ſouthing and the obſerved one, on the ſame day; then ſay:

As the daily difference, is to the obſerved difference;

So is 360 degrees, to the difference of longitude ſought.

For, As the whole difference ariſes in a day, or by the running thro' 360°; conſequently any part of that difference will require a proportional part of 360 degrees.

Exam. *Suppoſe at ſea, the moon was obſerved to paſs the meridian on the 18th day of June, 1753, at 57 min. after one in the morning: Required the longitude of that place?*

At London the moon paſſes the meridian on the 18th of June, at 1 h. 47 m., and on the 19th day, at 2 h. 31 m.; the difference is 44 min.; and the obſerved time is 10 min. later than at London.

Then as 44 min. : 10 min. :: 360° : ($\frac{3600}{44}$ =) 81° 49′. Which ſhews that place to be 81° 49′ to the weſt of the meridian of London.

1124. As the Tables of the moon's motions are not yet arrived at the wiſhed for accuracy, conſequently the times of her paſſing the meridian of any place, as ſhewn by an Ephemeris, are not ſo true as they might be, and therefore the diff. long. found by the time of the moon's ſouthing may err about 2 degrees; and ſhould the time of her paſſing the meridian be ill obſerved, the error may be much greater: It has therefore been propoſed to keep an account of longitude by a time-keeper, or kind of clock, that ſhould always ſhew the true time under the meridian of ſome one place; conſequently was the time of the day, found in any other place, compared with the time then ſhewn by ſuch a clock, the difference of longitude between thoſe places would be determined: But the difficulties attending the conſtruction of ſuch an inſtrument have been hitherto found too great to be overcome. Indeed the ingenious Mr. Harriſon has removed ſome of, if not all, the capital obſtructions; and his judicious friends ſuſpect he will intirely perfect his moſt elaborate machine: He has received ſome gratuities from the public for the advances he has already made towards the ſolution of this intricate problem of the longitude; and it is wiſhed he may merit the whole reward allotted by the Government for the diſcoverer of this ſo much deſired acquiſition in navigation.

1125. Upon the whole, it appears that there are many means by which a ſhip's place may be found at ſea, nearly exact enough for navigating her to places whoſe longitudes are almoſt as incorrectly known as the ſhip's place; and was the method of finding the longitude at ſea correctly known, the ſhips muſt then keep as good a look out for land as they do now, and alſo keep their account of dead reckoning: Therefore would ſeamen put in practice all the precepts that are given them for this purpoſe, they might proceed on their reſpective voyages, and (which is ſuſpected now to be the caſe) have very little concern about the perfecting the diſcovery of the longitude.

SECTION X.

1126. *Of a Sea Journal.*

A Sea journal is a book wherein is truly entered the moſt remarkable daily occurrences relating to the ſhip during her voyage outward and homeward.

There are various ways of keeping ſea journals, according to the different notions of mariners concerning what articles are to be entered.

Some writers direct the keeping ſuch a kind of journal, which is only an abſtract of each day's tranſactions, ſpecifying the weather, what ſhips or lands were ſeen, accidents on board, the latitude, longitude, meridional diſtance, courſe and run: Theſe particulars are to be drawn from the ſhip's log-book, or that kept by the Perſon himſelf, for moſt good mariners keep private log-books.

Other authors recommend the keeping but of one account, including the log-book and all the work of each day, with the deductions drawn therefrom: This method is uſed in this treatiſe, on account of repreſenting to the beginner the whole of each day's work; but when he is well verſed in this method, he may abridge what part of it he pleaſes: Altho' it is conceived, that a journal neatly kept, with all the particulars of the work commodiouſly ranged, would give more ſatisfaction to thoſe who might have occaſion afterwards to inſpect it, than a journal containing the heads only, and all the intermediate parts ſuppreſſed.

The method here choſe to introduce the young mariner into this moſt capital part of navigation, is, by ſhewing him firſt how to work a few ſeparate days works independent one of the other, and then to proceed to a continued journal of ſeveral ſucceſſive days works; for the doing of which it was judged neceſſary to premiſe the following obſervations.

1127. I. That the day is ſuppoſed to begin at noon, and the day's work relates to the tranſactions done in the time between the noon of one day and the noon of the following day.

II. If there is an obſervation for an amplitude or an azimuth; let that amplitude or azimuth be worked as ſhewn between art. 1070, and 1076; and then find the variation as ſhewn at art. 1077; taking care in theſe operations that the declination of the day be fitted to the proper time, and longitude, as ſhewn arts. 964, 965.

III. Correct each courſe by the variation thus found, as at art. 1078; alſo correct theſe corrected courſes by the proper allowance for leeway, as ſhewn at arts. 1080, 1081.

IV. Write theſe corrected courſes in a Traverſe table, ſum up the knots and fathoms belonging to thoſe hours the ſhip kept on the ſame courſe, and write the ſeveral ſums as diſtances in the Traverſe table againſt their reſpective courſes.

V. Complete the Traverſe table as by art. 695, find the preſent latitude and longitude as ſhewn in art. 786, 787, and the following examples, and then will the ſhip's place be obtained by dead reckoning.

1128.

1128. EXAMPLE I. *Auguſt 25th, 1753. Yeſterday noon we were in the latitude of 46° 28′ N., longitude 22° 18′ W., and have ſailed till this day noon as by the log-board, the tide having all the time ſet S. b. E. $2\frac{1}{2}$ miles an hour: Required the ſhip's place, and the direct courſe and diſtance made good?*

LOG-BOARD.

H.	K.	F	Courſes	Winds
1	6	3	NNE.	Weſt
2	6	2		
3	6	5		
4	6	4		
5	6	0		
6	6	1	ENE	NW.
7	6	6		
8	5	8		
9	5	6		
10	5	4		
11	5	5		
12	5	3	E. b. S	North
1	5	9		
2	6	2		
3	6	0		
4	6	3		
5	6	4		
6	7	0	SSE.	NW.
7	6	8		
8	7	3		
9	7	5		
10	7	1		
11	7	9		
12	7	3		

TRAVERSE TABLE.

Courſes	Dif	N.	S.	E.	W.
NNE.	31	28,6		11,9	
ENE.	35	13,4		32,3	
E. b. S.	36		7,0	35,3	
SSE.	51		47,1	19,5	
S. b. E.	60		58,8	11,7	
		42,0	112,9	110,7	Dep.
			42,0		
		D. lat.	70,9		

Depart. lat. = 46° 28′ N. M. P = 3156
Diff. lat. = 1 11 S.

Preſ. lat. = 45 17 N. M. P. = 3054

Sum lats. = 91 45 M. D. lat. = 102

Middle lat. = 45 52

Co-middle lat. = 44 08

Dep. longitude = 22 18 W.
Difference long. = 2 39 E. Or, 2° 40′.

Preſent long. = 19 39 W.

Direct courſe = S. 57° 15′ E.
Diſtance = 131 miles.

The courſes and winds in the log-board being examined, it appears that the ſhip goes large, and has no leeway; therefore the ſeveral courſes from the log-board are entered in the Traverſe table without alteration.

Next, the fathoms and knots belonging to each courſe are ſummed up; and the reſults are put in the column of diſtances in the Traverſe table; and to theſe courſes and diſtances the whole difference of latitude and departure are found. (695)

Then the preſent lat. is found by art. 655; the co-mid. lat. by 758; the preſent long. by 777; and the courſe and diſtance by 692.

Or by Mercator's. Having found the preſent lat., find the meridional diff. lat. = 102 by art. 765; and the courſe and diſt. by 692.

Then the diff. long. being found by art. 778, will be 2° 40′, differing by one mile from that found by middle latitude.

1129. **Example II.** *May 24, 1753. Being yeſterday noon in the latitude of 49° 27′ N., and longitude 16° 02′ W., we have ſailed till this day noon, as by the log-board, in a current ſetting NW. 2¼ miles an hour: Required the ſhip's place, together with her direct courſe and diſtance ſailed?*

LOG-BOARD.

H.	K.	F	Courſes	Winds
1	5	2	SWb. W	NWbW
2	5	3		
3	5	2		
4	4	4		
5	4	3		
6	4	2		
7	5	5	SE. b. S	SW.b.S.
8	5	1		
9	6	4		
10	6	2		
11	[illegible]	[illegible]		
12		3		
1	6	2		
2	7	4	NE.	ESE.
3	7	4		
4	7	6		
5	6	4		
6	6	3		
7	6	5		
8	5	2	NNE	Eaſt
9	5	3		
10	5	4		
11	5	5		
12	4	2		

TRAVERSE TABLE.

Courſes	Diſ	N.	S.	E.	W.
SW.	29		20,5		20.5
SE.	43		30.4	30.4	
NE. b. N.	42	34.9		23.3	
N. b. E.	26	25,5		5,1	
NW.	54	38.2			38,2
		98.6	50,9	58,8	58,7
		50,9		58,7	
		47.7	D. lat.	0.1	Dep.

Dep. lat. = 49° 27′ N. Mer. pts. = 3423
Diff. lat. = 0 48 N.

Preſ. lat. = 50 15 N. Mer. pts. = 3498

Sum lats. = 99 42 M. D. lat. = 75

Middle lat. = 49 51

Co-mid. lat. = 40 09

Dep. long. = 16 02 W.
Diff. long. = 00 00 W.

Preſ. long. = 16 02 W.

Courſe is due North.
Diſtance 48 miles.

As each courſe on the log-board is 6 points diſtant from the wind therefore one point leeway is allowed to each, and the courſes thus corrected (art. 1081) are put in the column of courſes in the Traverſe table. Then the Traverſe table is completed to the diſtances belonging to th reſpective courſes, and the whole diff. lat. is found to be 47,7 miles o northing, and but $\frac{1}{10}$th part of a mile of departure; therefore it may b concluded that the ſhip would have got to her preſent place by a courſ due north, and conſequently ſhe has not at all altered her longitude.

In theſe two examples, and the following ones, it was not though neceſſary to take any more than one fractional place in the ſeveral differences of latitudes and departures, altho' the Traverſe table gives two ſuch places.

1130. Example III. *June 27, 1753. Being yeſterday noon in latitude 25° 30′ S., and longitude 10° 15′ E., we have ſailed till this day noon, as per log-board, in a current ſetting ſouth 2½ miles an hour, the variation 1½ point weſt: Required the ſhip's place?*

Log-board.

H.	K	F.	Courſes	Winds
1	6	0	SW.	WNW.
2	6	2		
3	6	4		
4	6	0		
5	5	2		
6	6	0	S. b. W.	W. b. S.
7	5	1		
8	5	4		
9	5	2		
10	5	3		
11	5	5		
12	5	2	SSW.	Weſt
1	5	2		
2	5	0		
3	4	6		
4	5	0		
5	5	1		
6	5	2	SE. b. S.	SW. b. S.
7	5	4		
8	5	4		
9	6	0		
10	6	0		
11	5	4		
12	5	5		

Traverse Table.

Courſes	Dif	N.	S.	E.	W.
S. b. W ½ W	30		28,7		8,7
S. b. E. ½ E.	32		30,6	9,3	
S. ½ E.	30		29,9	2,9	
SE. b. E ½ E	39		18,4	34,4	
S b E ½ E.	60		57,4	17,4	
		D. lat	165,0	64,0	8,7
				8,7	
				55,3	Dep.

Diff. lat. = 2° 45′ S.
Dep. lat. = 25 30 S. Mer. pts. 1583

Preſ. lat. = 28 15 S. Mer. pts. 1768

Sum lats. = 53 45 M. diff. lat. 185

Mid. lat. = 26 52

Co-mid. lat. = 63 08

Dep. long. = 10 15 E.
Diff. long. = 1 02 E. Or, 1° 01½′ E.

Preſ. long. = 11 17 E.

Courſe is S. 18° 30′ E.
Diſtance is 174 miles.

The courſes and winds in the log-board being examined, it appears that the ſhip is cloſe hauled on each tack, and one point leeway being allowed (1081) reduces the courſes to SW. b. S., S. b. W., SE., and take a courſe for the current S.; theſe ſeveral courſes being corrected by art. 1078 for the variation 1½ point weſt, give thoſe in the Traverſe table; to which the whole difference of latitude and departure is to be found as before.

And hence the preſent latitude and longitude may be found either by middle latitude, or Mercator's ſailing: For as the ſhip is ſo near the equator, the difference will be almoſt inſenſible.

If a greater accuracy is required, which is very rarely wanted, eſpecially in ſuch ſmall latitudes, the diff. of long. may be found to each courſe, as ſhewn in the arts. 789, 790, and thence the whole diff. long. may be collected; but there will be no material difference gained by ſuch operation.

1131. Example IV. *Yeſterday noon we were in lat.* 14° 40′ *N., long.* 57° 25′ *W.*; *we have ſailed till this day noon, as per log-board, in a current ſetting WSW.* ½ *W.* ½ *mile an hour*; *the variation was N.* ½ *point weſt: Required the ſhip's place, and her courſe and diſtance to the Iſland of Barbadoes?*

Log-board.

H.	K	F	Courſes	Winds
1	5	0	SWbS½W	WNW½W
2	5	2		
3	5	2		
4	6	0		
5	6	3	SWb.W½W	NW.½W.
6	6	4		
7	6	2		
8	7	0		
9	7	3		
10	6	0		
11	6	2		
12	6	4		
1	7	0	SW.	WNW.
2	7	0		
3	7	1		
4	7	3		
5	6	0		
6	6	2		
7	6	4	S.b.E.½E	SW.½W.
8	7	0		
9	7	4		
10	8	0		
11	8	2		
12	7	4		

Traverse Table.

Courſes	Dif	N.	S.	E.	W.
SSW.	21		10,4		8,0
SW.	52		36,8		36,8
S b.W½W	41		39,2		11,9
SE. b. S.	44		36,6	24,5	
WSW.	12		4,6		11,1
		D. lat	136,6	24,5	67,8
					24,5
				Dep	43,2

Diff. lat. = 2° 17′ S.
Dep. lat. = 14 40 N.

Preſ. lat. = 12 23 N.

Sum lats. = 27 03
Mid. lat. = 13 31
Co-mid. lat. = 76 29

Dep. long. = 57 25 W.
Diff. long. = 0 45 W.

Preſ. long. = 58 10 W.

Here the ſhip's place is found; namely, in lat. 12° 23′ N., and longit. 58° 10′ W.

Now to find her courſe and diſtance to Barbadoes.

Barbadoes's lat. = 13° 00′ N.
Preſent lat. = 12 23 N.

Diff. lat. = 0 37 N.

Sum lats. = 25 23
Mid. lat. = 12 41
Co-mid. lat. = 77 19

Barbadoes's long. = 59° 50′ W.
Preſent long. = 58 10 W.

Diff. longit. = 1 40 = 100 m.
The departure = 97,5
The courſe is N. 69° 15′ W.
The diſtance 104 miles.

In this example, the manner of correcting the courſes and finding the ſhip's place is the ſame as in the preceding ones.

But the courſe and diſtance ſhe has ſtill to go to arrive at her port, is found by the Traverſe table according to the directions in art. 769. Or, when the latitudes concerned are above 40°, the operation may be beſt performed by the directions for the uſe of the Traverſe table in art. 770.

1132.

1132. Example V. *Yeſterday noon we were in lat.* 33° 40′ *N., long.* 16° 20′ *W., the ſun was obſerved to ſet* 50° 18′ *from the north point of the compaſs; we have ſailed till this day noon, as per log-board, in a current ſetting WSW.* 1½ *miles an hour: Required the ſhip's place, and her courſe and diſtance to the weſt end of the Iſland of Madeira, June* 4*th*, 1753?

Log-board.

H	K.	F.	Courſe.	Winds
1	6	2	S. b. W	Weſt
2	6	0		
3	6	3		
4	7	0		
5	7	2		
6	7	3		
7	7	2	SW.b.S.	W.b.N.
8	7	2		
9	7	4		
10	7	6		
11	7	4		
12	8	1		
1	8	0		
2	8	5		
3	8	2		
4	7	5	SWb.W	NW.
5	[illegible]	3		
6	[illegible]	6		
7	[illegible]	4		
8	[illegible]	0		
9	6	2		
10	[illegible]	1		
11	6	3		
12	6	1		

Traverse Table.

Courſe	Dif.	N.	S.	E.	W.
S. 01° E.	40		40,0	0,7	
S. 10 W.	70		68,9		12,2
S. 44 W.	58		41,7		40,3
S. 55 W.	36		20,6		29,5
		D. lat.	171.2	0,7	82,0
					0,7
				Dep	81,3

Before the courſes can be corrected to put in the Traverſe table, the variation of the compaſs muſt be found from the ſun's true amplitude; which may be found by art. 1070, or by working the proportion in art. 1071, either by logarithms or the Gunter.

June 4th, 1753, the declination is 22° 30′ N.
As coſ. 33° 40′ : Rad : : ſin. 22° 30′ : ſin. 27° 22′.
So that the true amplitude = 62° 38′ W.
Mag. amplitude = 50 18
Variation = 12 20 W.

The courſes in the log-board being corrected by this variation and the leeway, will give the courſes fitted for the Traverſe table.

Dep. lat. = 33° 40′ N.
Diff. lat. = 2 51 S.
Pref lat. = 30 49 N.
Sum lats. = 64 29
Mid. lat. = 32 14
Co-mid. lat. = 57 46
Dep. long. = 16 20 W.
Diff. long. = 1 36 W.
Pref. long. = 17 56 W.

M. P.
Madeira's lat. = 32° 25′ N. 2058
Pref. lat. = 30 49 N. 1945
Diff. lat. = 1 36 113
Sum lats. = 63 14
Mid. lat. = 31 37
Co-mid. lat. = 58 23
Madeira's long. = 17 21 W.
Pref. long. = 17 56 W.
Diff. long. = 0 35 W.
The courſe (770) = N 17° 15′ E.
The diſtance = 101 miles.

In the work for the amplitude, the lat. at ſun-ſet was taken the ſame as at noon; for altho' there were about 46 m. of ſouthing in that time, and ſo the lat. at ſun-ſet was about 32° 54′, yet the amplitude being only about 15′ leſs, the alteration in variation would ſcarcely affect the diff. lat. and dep. found from the courſes ſo corrected

1133. Example VI. *Auguſt 3d, 1753. Being yeſterday noon in lat. 19 30′ S., long. 0° 10′ E.; this forenoon we obſerved the ſun's altitude to b 10° 40′, when he was 80° 30′ from the north point of the compaſs; we hav ſailed till this day noon, as per log-board, in a current ſetting by the compaſ WNW. ½ mile an hour: Required the ſhip's place, with her direct courſ and diſtance to the Iſland of St. Helena?*

LOG-BOARD.

H.	K.	F.	Courſes	Winds
1	5	7	N. b. E	E. b. N
2	6	2		
3	6	4		
4	6	3		
5	6	1		
6	6	0		
7	5	8	North	ENE.
8	5	4		
9	5	0		
10	5	3		
11	5	6		
12	5	9		
1	5	7		
2	6	4	NNW.	NE.
3	6	8		
4	7	0		
5	7	3		
6	7	6		
7	7	5		
8	7	0		
9	7	2		
10	7	4		
11	6	3		
12	6	0		

TRAVERSE TABLE.

Courſes	Dif.	N.	S.	E.	W.
N. 13° 30′ W.	38	36,9			8,9
N 24 45 W.	38	34,5			15,9
N. 47 15 W.	76	51,7			55,6
N 81 00 W.	12	1,9			11,8
		125,0			92,2
		D. lat.			Dep.

Before the courſes can be corrected, an azimuth muſt be worked as in arts. 1074, 1075.

	90° 00′		90° 00′		90° 00
Decl.	17 27	Lat.	19 30	Alt.	10 40
A =	107 27	Co-lat.	70 30	Co-alt.	79 20
D =	8 50			Co-lat.	70 30
	116 17		58° 08′ = ½ ſum	D =	8 50
	98 37		49 19 = ½ diff.		

Then by the Gunter, the extent from 58° 08 to 79° 20′ on the ſines, will reach from 70° 30 to ſome point beyond 90°; reſt one foot there and extend the other to 49° 19′; then this extent will reach from the beginning of the verſe ſines to the verſed ſine of 67°, the azimut ſought, as the latitude is ſouth. Hence the variation will be 13° 30′ W.; with which th courſes in the log-board are to be corrected.

For the ſhip's place.

Dep. lat. = 19° 30′ S.
Diff. lat. = 2 05 N.
Preſ. lat. = 17 25 S.
Sum lats. = 36 55
Mid. lat. = 18 27
Co-mid. lat. = 71 33
Dep. long. = 0 10 E.
Diff. long. = 1 36 W.
Preſ. long. = 1 26 W.

For the bearing and diſt. of Helena.

St. Helena's lat. = 16° 00′ S. M. P. 97
Preſ. lat. = 17 25 S. 106
Diff. lat. = 1 25 8
Sum lats. = 33 25
Mid. lat. = 16 42
Co-mid. lat. = 73 18
St. Helena's lon. = 5 53 W.
Preſ. long. = 1 26 W.
Diff. long. = 4 27 = 267 m
Courſe N. 71° 30′ W. (770
Diſtance 270 miles.

Her

Here the azimuth is worked with yeſterday's lat.; but had it been work'd with this day's, the variation would have been 12° 30′, the diff. lat. 126 m., and the dep. 90 m.

1134. In the following Journal are introduced almoſt all the circumſtances that can attend a day's work in any voyage: The ſhip is taken from the river *Thames*, conducted thro' the *Downs*, down the *Engliſh channel*, and from thence over the *Ocean* till ſhe is brought within ſight of the port ſhe is bound to, which is *Fonchal* in the iſland of *Madeira*. In this navigation, care has been taken to point out the uſual buſineſs done in like circumſtances of wind and weather; the courſes and diſtances run down the Channel are ſuch as produce the bearings and diſtances of the places mentioned, and 'tis not unuſual for many veſſels to keep a track not very different from what is here aſſigned. Indeed the runs inſerted in the log-boards, after the ſhip has taken her departure from the Lizard, are rather ſomewhat greater than can be expected from any veſſel in like weather: But ſuch long days runs were uſed to ſave 4 or 5 days works, which muſt have been added to bring the ſhip to her port, had the uſual runs been introduced. All the aſtronomical obſervations are fitted to the times and places; and 'tis apprehended that the whole is conducted in ſuch a manner as 'tis poſſible to have happened.

To the obſervations in article 1127 it may be proper to annex the following ones.

1135. I. That as each day's account is ſettled at the noon ending that day, therefore the ſun's declination of the day following is uſed: Thus, in ſetling Sunday's account, the declination of Monday is taken; becauſe the latitude by obſervation at the end of Sunday is the ſame as at the beginning of Monday.

II. The preſent longitude each day is found by middle latitude; but the bearings and diſtances to the Lizard and Madeira are found by Mercator's ſailing; the one being rather preferable, for its eaſe of working, in the former caſe, the other in the latter.

III. As the greateſt trouble in uſing the Traverſe table is the finding therein a correſponding difference of latitude and departure, or meridional difference of latitude and difference of longitude, nearly equal to two given numbers, it may perhaps be found moſt convenient, as the Traverſe table to the points of the compaſs at art. 711 lies in two openings or folio's, firſt to find the neareſt correſponding numbers in one of thoſe folio's, marking what courſe they ſtand with, and then to turn to the degrees neareſt that courſe in the large Traverſe table, art. 712, and near that place the given numbers will be found more accurate, with but little trouble. Thus to find the courſe to 672 meridional diff. lat. and 353 diff. long. In page 307, the neareſt numbers 67,03 and 35,82 ſtand with $2\frac{1}{2}$ points, or about 28 deg. Then turning to 28 deg., and not finding them there, turn to 27°, and the numbers 67,26 and 35,39 anſwer to 27° 45′ courſe.

In moſt Journals, the week days are marked by the planets characters. Thus Sunday is ☉, Monday ☽, Tueſday ♂, Wedneſday ☿, Thurſday ♃, Friday ♀, Saturday ♄.

1136. *A* Journal *of a voyage in the year* 1752. *In the Hopewell of London, from England towards Madeira.* Lucas Trimmer, *Commander. Kept by* Francis Drake, *Mate.*

Winds.	Remarks on board.
SSW.	♂. 26th September. At 5 A. M. the pilot came on board; then weigh'd and ſail'd from Cherry-Garden. At 11 came to with the beſt bower * at Blackwall.
From SSW. to NNW.	☿. 27th September. Freſh gales and cloudy weather with rain. At 5 A. M. weigh'd and ſail'd; and at 9 came to an anchor at Graveſend, and clear'd ſhip.
W. b. S.	♃. 28th. September. At 4 P. M. weigh'd and ſail'd, moderate weather: At 9 came to with the beſt bower at the Nore in 9½ fathoms; freſh gales: At 4 A. M. weigh'd and ſail'd. At 11 came to anchor in the Downs in 7 fath. Deal-caſtle bearing W. ½ S. diſtant 3 miles.
W. b. S.	♀. 29th September. At 1 P. M. ſent the pilot aſhore. Theſe 24 hours, the firſt and middle parts moderate and fair, the latter part ſtrong gales and cloudy.
Variable from S. b. W. to Weſt.	♄. 30th September. Strong gales and cloudy. At 2 P. M. veer'd out the long ſervice † of the beſt bower; got top-gallant yards down. At 4 P. M. ſtruck yards and top-maſts. Theſe 24 hours, had very hard gales of wind.
SW.	☉. 1ſt October. Theſe 24 hours, for the moſt part freſh gales. At 4 A. M. hove up beſt bower, and let go ſmall bower *. At 9, hove up ſmall bower, and let go beſt bower again. People employed in making points and gaſkets.
W. b. N.	☽. 2d October. At 6 P. M. ſtrong gales with heavy-rain. At 8, veer'd out long ſervice, and let go the ſheet anchor * under foot. At 9 A. M. hove up ſheet anchor.
NW.	♂. 3d October. Theſe 24 hours, for the firſt and middle parts moderate and fair; the latter part ſtrong gales.
NW.	☿. 4th October. Theſe 24 hours, freſh gales and fair. At 3 P. M. got top-gallant maſts down. At 10 A. M. got yards and top-maſts up.

---

* Note, It is cuſtomary in moſt ſhips to have three kinds of anchors, namely:
The ſmall bower, uſed to fix the ſhip in ſtill water and calm weather.
The beſt bower, a larger anchor, for riding in rough weather.
The ſheet anchor, or largeſt, for fixing the ſhip in ſtormy weather.

† The firſt 30 fathoms of cable next the anchor is called *ſhort ſervice*; and when the remaining part is veered out, it is called the *long ſervice*.

Journal from England towards Madeira.

LOG-BOARD.

H.	K.	F	Courſes	Winds
2			S.b.W$\frac{1}{4}$W	N.$\frac{1}{2}$W.
4				
6				
8				
10				
12			W.	N. b. W.
2			SWbW$\frac{1}{4}$W	
4				
6			WNW$\frac{1}{2}$W.	N. $\frac{1}{2}$ W.
8			WSW.	N. b. E.
10				
12				

Remarks on board.

♃. 5th October. At 2 P.M. hove ſhort and hoiſted in the long-boat.

At 4, weigh'd and ſail'd in company with a 20 gun man of war and 40 ſail of merchantmen.

At 6, South-Foreland bore NNW. diſt. 4 m.

At 2 A. M. Fairlee bore N. diſt. 6 miles.

At 6, Beachy bore N. b. W. 6 miles.

At 8, Beachy bore NE. b. E. 9 miles.

Freſh gales and clear. Several ſhips ſtanding up Channel. Cloſe reeft both top-ſails.

At 12, Bembridge point bore WNW. 27 m. Still in company with the fleet.

LOG-BOARD.

H.	K.	F.	Courſes	Winds
2			WSW.	N. b. E.
4	4	6	W. $\frac{1}{4}$ S.	
6	5	5		
8	5	0		
10	5	1		
12	4	6		
2	5	0		
4	4	5		
6	4	4		
8	4	0		
10	4	2	SbW.$\frac{1}{2}$W.	NNE.
12	5	0		

Remarks on board.

♀. 6th October. Freſh gales and clear. At 4 P. M. parted with the fleet, they being bound to Spithead. Dunnoſe bearing WNW. diſtance 21 miles.

At 5, let out one reef of each top-ſail.

At 7 A. M. Portland lights bore NNW. 9 m.

At 10 ditto bore NE. 12 miles.

Fourteen ſail in ſight.

LOG-BOARD.

H	K.	F.	Courſes	Winds
2	5	6	Sb.W$\frac{1}{2}$W.	NNE.
4	5	5		
6	4	0		
8	3	5	Wb.N$\frac{1}{2}$W	North
10	4	1		
12	4	3		
2	3	0		
4	3	6	SW. $\frac{1}{4}$ W.	NW.b.W.
6	4	5		
8	5	2		
10	5	4		
12	5	6		

Remarks on board.

♄. 7th October. Cloudy weather, freſh gales.

At 4 P. M. Start bore W. b. N. diſt. 12 m.

At 8 ditto bore E. b. N. 9 m.

At 4 A. M. Edyſtone bore NE.b.E.$\frac{1}{2}$E. 12 m.

At 6, got up both top-gallant maſts and yards.

At 7$\frac{1}{2}$, Lizard bore W. b. N.

Several ſhips ſtanding up Channel.

At noon Lizard bore N. b. W. diſt. 21 miles.

For, From 7$\frac{1}{2}$ h. to 12 h. is 4$\frac{1}{2}$ hours.

4$\frac{1}{2}$ hours, at 5,4 miles an hour, is 24 miles.

Between SW.$\frac{1}{4}$W. and W. b. N. is 4$\frac{3}{4}$ points.

Between SW.$\frac{1}{4}$W. and N. b. W. is 5$\frac{1}{4}$ points.

The other angle is 6 points.

Then 6 pts. : 4$\frac{3}{4}$ pts. : : 24 m. : 21 m. (340)

Journal from England towards Madeira.

LOG-BOARD.

H.	K.	F.	Courſes	Winds
2			Foggy & lay by	WSW.
4				
6	6	0	WSW. $\frac{1}{4}$ W.	NW. b. N. $\frac{1}{4}$ W.
8	6	4		
10	6	2		
12	7	5		
2	7	0		
4	7	3		
6	7	1		
8	7	0		
10	7	0		
12	7	6		

Remarks on board.

☉. 8th October. Theſe 24 hours, firſt part foggy, the latter part moderate gales and clear weather.

At 4 P. M. fog clear'd up. Shifted the Channel compaſs, where the variation was allow'd for, and put another into the bittacle.

Lizard bore N. $\frac{1}{2}$ E. diſtance 21 miles.

Variation $1\frac{1}{2}$ point to the weſt.

Leeway $\frac{1}{2}$ point.

Unbent our cables and ſtowed anchors.

At 2 A. M. ſet top-gallant ſails.

Obſerved ſun's merid. zen. diſt. = 54° 33′ S.
Declination = 6 31 S.

Lat. per obſervation = 48 02 N.

TRAVERSE TABLE.

Courſes	Dif.	N.	S.	E.	W.
S. b. E.	21		20,6	4,1	
SW. $\frac{1}{4}$ W.	140		94,0		103,7
		D. l	114,6	4,1	103,7 4,1
				Dep	00.6

Dep. lat. = 49° 57′ N.
Diff. lat. = 1 55 S.
Preſ. lat. = 48 02 N.
Sum lats. = 97 59
Middle lat. = 48 59
Dep. long. = 5 14 W.
Diff. long. = 2 12 W.
Preſ. long. = 7 26 W.
Lizard bears N. 41° E.
Diſtance 152 miles.

Here the lat. by account agreeing with the lat. by obſervation, it is judged that the ſhip's place is truly aſcertained.

Ship's lat. = 48° 02′ N. Meridional parts = 3294,6
Madeira's lat. = 32 38 N. Meridional parts = 2073,4
Diff. lat. = 15 24 Merid. difference lat. = 1221.
Or 924 miles.
Ship's longit. = 7 26 W.
Madeira's long. = 16 51 W.
Diff. long. = 9 25 = 565 miles.
Iſland of Madeira bears S. 24° 45′ W. Diſtance 1015 miles.

Here the ſhip is ſuppoſed to ſail from the Lizard; and as the Lizard bore N. $\frac{1}{2}$ E., the courſe muſt be on the oppoſite point, which is S. $\frac{1}{2}$ W.; and this courſe corrected by the variation, as at art. 1078, gives S. b. E.; alſo the other courſe WSW. $\frac{1}{4}$ W. being corrected both for the variation and leeway (arts. 1078, 1081), the Traverſe table, and other work for the preſent latitude and longitude, is performed by the obſervations in art. 1127.

Then the bearing and diſtance to Funchal in the Iſland of Madeira is found, as in art. 770, working by the Traverſe table.

Journal

Journal from England towards Madeira.

LOG-BOARD.

H	K.	F.	Courſes	Winds
2	7	6	Weſt	S. b. W.
4	8	4		
6	8	6		
8	8	9		
10	9	0		
12	8	6		
2	8	3		
4	8	4		
6	8	1		
8	8	6		
10	8	3		
12	8	0		

Remarks on board.

☽. 9th October. Theſe 24 hours ſtiff gales with drizling rain.

Variation 1½ point weſt.

At 4 P. M. ſpoke with the Charming Molly bound from Carolina to London.

At 8, took in top-gallant ſails.

At 4 A. M. took ſingle reef in each T. S. *

People employ'd in making points.

Obſerv'd ſun's merid. zen. diſt. = 54° 09′ S.
Declination = 6 54 S.

Latit. by obſervation = 47 15 N.

Dep. lat. = 48° 02′ N. or laſt day's lat.
Diff. lat. = 0 59 S. as by Trav. tab.
Preſ. lat. = 47 03 N. as by account.

Here the lat. by obſervation differs 12 minutes from that by account.

TRAVERSE TABLE.

Courſes	Dif.	N.	S.	E.	W.
WSW½W	202		58,6		193,3

Therefore, before the longitude can be found, the dead reckoning muſt be corrected by art. 1113, as the courſe is nearer the parallel than the meridian.

Then to the diff. lat. 58,6 and depart. 193,3, the diſt. is 205.

And to the diſt. 205, and diff. lat. by obſerv. 47, the dep. is 199,5.

Now Dep. lat. = 48° 02′ N.
Preſ. lat. by obſ. = 47 15 N.
Sum lats. = 95 17
Middle lat. = 47 38

Dep. long. = 7° 26′ W.
Diff. long. = 4 50 W.
Preſ. long. = 12 16 W.

M. P.
Lizard's lat. = 49° 57′ N. 3470
Ship's lat. = 47 15 N. 3225

Diff. lat. = 2 42 245

Or 162 miles.
Lizard's long. = 5 14 W.
Ship's long. = 12 16 W.

Diff. long. = 7 02 = 422 m.
Lizard bears N. 59° 45′ E.
Diſtance 324 miles.

M. P.
Madeira's lat. = 32° 38′ N. 2073
Ship's lat. = 47 15 N. 3225

Diff. lat. = 14 37 1152

Or 877 miles.
Madeira's long. = 16 51 W.
Ship's long. = 12 16 W.

Diff. long. = 4 35 = 275 m.
Madeira bears S. 13° 30′ W.
Diſtance 903 miles.

---

* Mariners in their Journals uſe abbreviations of words; ſuch as T. S. for top ſails, B. T. S. both top ſails, and many others.

Journal from England towards Madeira.

LOG-BOARD.

H.	K	F	Courſes	Winds
2	9	2	S. ½ E.	NNW.
4	10	0		
6	9	5		
8	10	0		
10	10	6		
12	10	2		
2	10	4		
4	9	6		
6	10	0		
8	10	4		
10	9	8		
12	10	0		

Remarks on board.

♂. 10th October.
Theſe 24 hours hard gales and clear weather.
At 6 P. M. cloſe reef'd the top ſails.
At 6 A. M. a ſail ſtanding to northward.
At noon Cape Finiſterre bore N. 85° E., diſtant 25 miles.
Variation 1½ W.

Obſerved ſun's mer. zen. diſt. 50° 33′ S.
Declination 7 16 S.

Latitude by obſervation 43 17 N.
Dep. lat. 47 15

Diff. lat. 3 58 = 238 m.

Departed lat. = 47° 15′ N.
Diff. lat. = 3 42 S.

Pres. lat. = 43 33 N. by acct.
Pres. lat. = 43 17 N. by obſer.

TRAVERSE TABLE.

Courſe	Dif.	N.	S.	E.	W.
SSE.	240		221,8	91,8	

Here the latitude by account falls ſhort of the latitude by obſervation. Therefore before the longitude can be found, the account of departure muſt be corrected by art. 1112, as the courſe is only two points from the meridian.

Now to diff. lat. 221,8 and dep. 91,8, the courſe is SSE.
To courſe SSE. and diff. lat. 238, the correct departure is 99,5.

Then, Sum lats. = 90° 32′
Middle lat. = 45 16
Co-middle lat. = 44 44

Dep. long. = 12° 16′ W.
Diff. long. = 2 23 E.
Pres. long. = 9 53 W.

		M. P.
Lizard's lat.	= 49° 57′ N.	3470
Ship's lat.	= 43 17	2886
Diff. lat.	= 6 40	584

Or = 400 miles:
Lizard's long. = 5° 14′ W.
Ship's long. = 9 53 W.

Diff. long. = 4 39 = 279 m.
Lizard bears N. 25° 30′ E.
Diſtance 443 miles.

		M. P.
Madeira's lat.	= 32° 38′ N.	2073
Ship's lat.	= 43 17	2886
Diff. lat.	= 10 39	813

Or = 639 miles.
Madeira's lon. = 16° 51′ W.
Ship's longit. = 9 53

Diff. longit. = 6 58 = 418 m.
Madeira bears S. 26° 45′ W.
Diſtance 715 miles.

Journal from England towards Madeira.

LOG-BOARD.

H.	K.	F.	Courſes	Winds
2	10	6	W.b.S¼W	Sb.W¼W.
4	10	2	Leeway	1 point
6	11	0	SSW.	W.
8	10	3	Leeway	1 point
10	9	7		
12	9	6	Wb,N¼W	SSW ¾W.
2	10	2	Leeway	1 point
4	10	5		
6	10	8	SW. ¾ W.	NWbW¼W
8	10	0	Leeway	1 point
10	10	1		
12	9	6		

TRAVERSE TABLE.

Courſes	D.	N.	S.	E.	W.
W. b. S.	42		8,2		41,2
S. ¼ E.	62		61,9	3,0	
W. b. N	61	12,1			60,8
SSW. ½W	83		73,2		39,1
		12,1	143,3	3,0	141,1
			12,1		3,0
			131,2		138,1

Dep. lat. = 43° 17′ N.
Diff. lat. = 2 11 S.
Lat. by account = 41 06 N.
Lat. by obſervation = 41 20 N.
Sum lats. = 84 37
Mid. lat. = 42 18
Dep. long. = 9 53 W.
Diff. long. = 3 14 W.
Pref. long. = 13 07 W.

			M. P.
Lizard's lat.	=	49° 57′ N.	3470
Ship's lat.	=	41 20 N.	2728
Diff. lat.	=	8 37	742

Or = 517 miles.
Lizard's long. = 5° 14′ W.
Ship's long. = 13 07 W.
Diff. long. = 7 53 W. = 473 m.
Lizard bears N. 32° 30′ E.
Diſtance 614 miles.

Remarks on board.

☿. 11th October.

Theſe 24 hours very hard gales and ſqually with rain.

Top ſails cloſe reeft.

At 10 P. M. ſpoke with the Princeſſa ſnow bound for London.

Obſerv. the ſun to ſet 66° from N. weſtward.

Hence find the true amplitude. (art. 1072.)

The lat. 43° 17′ N. Declin. 7° 16′ S.

To courſe 7° 15′ and diſt. 100, the dep. is 12,62.

To courſe 43° 15′ and d. lat. 12,62, the diſt. is 17.

To diſt. 100 and dep. 17, the courſe is 10°.

Therefore, the true ampl. is N. 80° 00′ W.
Mag. ampl. 66 00
Variation 14 00 W.

Or, allow 1¼ point variation.

Obſ. ſun's mer. zen. diſt. = 48° 59′ S.
Declination = 7 39 S.
By obſerv. Latitude = 41 20 N.
Dep. lat. = 43 17
Diff. lat. = 1 57
Or = 117 m.

Here the lat. by acct. having outrun the lat. by obſer. the dep. muſt be corrected by art. 1114, as diff. lat. and dep. are nearly equal.

Then to d. lat. 131,2 and dep. 138,1, the diſtance will be 190.

To diſt. 190 and true diff. lat. 117, find the dep. 149,7.

The ſum of both dep. 138,1 and 149,7 is 287,8.

The half ſum 143,9 = corrected departure.

			M. P.
Madeira's lat.	=	32° 38′ N.	2073
Ship's lat.	=	41 20 N.	2728
Diff. lat.	=	8 42	625

Or = 522 miles.
Madeira's lon. = 16° 51′ W.
Ship's long. = 13 07 W.
Diff. long. = 3 44 W. = 224.
Madeira bears S. 19° W.
Diſtance 552 miles.

Journal from England towards Madeira.

LOG-BOARD.

H.	K.	F.	Courſes	Winds
2	9	6	NWbW½W	SW. ½ W.
4	9	2	Leeway	2 points
6	9	5	S. ¾ W.	NE. ½ E.
8	8	5	Leeway	o point
10	8	7	WSW¼W	S. ¼ W.
12	7	2	Leeway	2 points
2	8	3	NNE ¼E.	S. ½ W.
4	8	7	Leeway	o point
6	7	6	SW.	SSE.
8	7	2	Leeway	1½ point
10	7	0		
12	6	4		

Remarks on board.

♃. 12th October.

Theſe 24 hours hard gales and cloudy weather, accompanied with hard rains.

Handed fore-top ſails.

At 10 P. M. heard a gun at a diſt.

At 2 A. M. ſaw to the NNE. ½ E. the flaſh of a gun, and after 56 beats of the pulſe at the wriſt we heard the ſound, by which we judged the diſt. to be about 11 miles (1140), and a ſhip in diſtreſs. Bore away to ſpeak with her.

At 6, having greatly overrun the diſt. and finding nothing, concluded ſhe was gone down, ſo hauled our wind, and ſtood to the SW.

No obſervation this day.

Variation 1¼ point weſt.

Depart. lat. = 41° 20′ N.
Diff. lat. = 0 24 S.
Preſ. lat. = 40 56 N.
Sum lats. = 82 16
Mid. lat. = 41 08
Depart. long. = 13 07 W.
Diff. long. = 2 06 W.
Preſ. long. = 15 13 W.

TRAVERSE TABLE.

Courſes	D.	N.	S.	E.	W.
NW. ¾ W	37	22,0			29,7
S. ½ E.	36		35,8	3,5	
W. b S.	30		6,6		33,6
N. b. E.	31	33,6		6,6	
SW. ¼ W.	6		37,6		41,5
		55,6	80,0	10,1	104,8
			55,6		10,1
		D. l.	24,4	Dep.	94,7

P. M.
Lizard's lat. = 49° 57′ N. 3470
Ship's lat. = 40 56 N. 2696

Diff. lat. = 9 01 774
Or = 541 miles.
Lizard's long. = 5° 14′ W.
Ship's long. = 15 13 W.

Diff. long. = 9 59 = 599 m.
Lizard bears N. 37° 45′ E.
Diſtance 685 miles.

M. P.
Madeira's lat. = 32° 38′ N. 2073
Ship's lat. = 40 56 N. 2696

Diff. lat. = 8 18 623
Or = 498 miles.
Madeira's lon. = 16° 51′ W.
Ship's long. = 15 13 W.

Diff. long. = 1 38 = 98 m.
Madeira bears S. 9° 00′ W.
Diſtance 505 miles.

Journal from England towards Madeira.

LOG-BOARD.

H.	K	F.	Courſes	Winds
2	6	7	S. ¼ W.	E.
4	8	0	Leeway	0 point
6	8	6	E. ¼ S.	SSE.
8	9	2	Leeway	1 point
10	8	5	W. b. N.	SW. b. S
12	8	5	Leeway	1 point
2	8	6	South	W.
4	9	0	Leeway	0 point
6	9	4	E.b.S.½E.	S.b. E.½E.
8	8	7	Leeway	2 points
10	8	8	S. ¾ E.	W.
12	9	3	Leeway	0 point

Remarks on board.

♀. 13th October.

Theſe 24 hours variable winds and hard gales, with cloudy and foggy weather.

Set fore-top ſails.

A great ſea ſetting to the northward, for which allow half a mile an hour.

At 6 P. M. handed fore-top ſail.

No obſervation to day.

Variation 1¼ point weſt.

Half a mile an hour, or 12 miles being allowed for the ſea ſetting northward, reduces the diff. lat. 58,7 to 46,7.

Tried the log-line and glaſs uſed this day, and find only 45½ feet on a mean for the length of each knot, and 28½ ſeconds for the run of the glaſs.

By this day's dead reckoning, the ſhip has run S. 52° 45′ E. diſt. 77 miles, which is about 3,208 miles an hour on a direct courſe.

But (by art. 1062) correcting the run, her way will be only 3,065 miles an hour, and her correct. diſt. will be 73,6 miles.

TRAVERSE TABLE.

Courſes	D.	N.	S.	E.	W.
S. b. E.	29		28,4	5,7	
ENE.	36	13,8		33,3	
Wb.N¼W	31	4,6			30,7
S.b.E.¼E.	35		33,9	8,5	
NEb.E¼E	36	18,5		30,9	
SSE.	36		33,3	13,8	
		36,9	95,6	92,2	30,7
			36,9	30,7	
			58,7	61,5	

Now the diff. lat. 46,7 and dep. 61,5, muſt be leſſened proportionally with the diſt. Then to courſe 52° 45′, and diſt. 73,6, the diff. lat. is 44,3, and the departure is 58,4.

Dep. lat. = 40° 56′ N.
Diff. lat. = 0 44 S.
Preſ. lat. = 40 12 N.
Sum lats. = 81 08

Mid. lat. = 40° 34′
Dep. long. = 15 13 W.
Diff. long. = 1 17 E.
Preſ. long. = 13 56 W.

M. P.
Lizard's lat. = 49° 57′ N. 3470
Ship's lat. = 40 12 N. 2638
Diff. lat. = 9 45 832
Or = 585 miles.
Lizard's long. = 5° 14′ W.
Ship's long. = 13 56 W.
Diff. long. = 8 42 = 522 m.
Lizard bears N. 32° 15′ E.
Diſtance 694 miles.

M. P.
Madeira's lat. = 32° 38′ N. 2073
Ship's lat. = 40 12 N. 2638
Diff. lat. = 7 34 565
Or = 454 miles.
Madeira's lon. = 16° 51′ W.
Ship's long. = 13 56 W.
Diff. long. = 2 55 = 175 m.
Madeira bears S. 17° 15′ W.
Diſtance 475 miles.

Journal from England towards Madeira.

LOG-BOARD.

H.	K.	F.	Courſes	Winds
2	9	4	S. 61° W.	SSE.
4	9	6	L.	W. 6 pts.
6	9	8		
8	9	8		
10	9	6		
12	9	0		
2	9	4		
4	10	0		
6	10	0		
8	10	0		
10				
12				

Remarks on board.

♄. 14th October.

Theſe 24 hours hard, but ſteady gales and cloudy weather.

At 4 P. M. ſet fore-top ſails.

At 8 A. M. obſerved the ſun's zen. diſt. to be S. 72° 55′.

At 10, ſaw the ſun again, its bearing was S. 25° 15′ E., zen. diſt. S. 54° 45′.

Handed both top ſails and fore ſail, and lay to under main ſail.

At noon made ſail.

Set fore ſail and both reef'd-top ſails.

TRAVERSE TABLE.

Courſes	Dif.	N	S.	E.	W.
S. 49° W.	202		122,5		152,5

Now having two zenith diſtances and the time between the obſervations, the latitude (by art. 1018) will be found to be 38° 20′ N.

Alſo the true azimuth at the ſecond obſervation, is } N. 142° 45′ E.
The obſerv'd magnetical azimuth, is N. 154 45 E.
The variation is 12 00 W.

Lat. by obſervation 38° 20′ N.
Departed lat. 40 12 N.
Diff lat. 1 52 = 112 miles.

Dep. lat. = 40° 12′ N.
Diff. lat. = 2 03 S.
Preſ. lat. by account = 38 09 N.
Lat. by obſervation = 38 20 N.
Sum lats. = 78 32
Mid. lat. = 39 16
Dep. long. = 13 56 W.
Diff. long. = 3 22 W.
Preſ. long. = 17 18 W.

Here, as the lat. by account has out-run the true lat., and the diff. lat. and dep. are nearly equal, the dep. muſt be corrected by art. 1114.

To d. lat. 122,5 and dep. 152,5, the diſt. is 196.
To diſt. 196 and d. lat. 112, the dep. is 160,4.
Then the ſum of departures is 312,9.
The half ſum is the true departure = 156,4.
With which, and co-middle lat., find difference of longitude.

Now a parallel of lat. thro' 38° 20′ in the variation chart, cuts the variation line of 12° in the longit. of 17°; and hence I judge my account of longitude is nearly right.

Liz. lat. = 49° 57′ N. M. P. 3470
Ship's lat. = 38 20 N. 2494
Diff. lat. = 11 37 976
Or = 697 miles.
Liz. long. = 5° 14′ W.
Ship's lon. = 17 18 W.
Diff. lon. = 12 04 W. = 724 m.
Lizard bears N. 37° 30′ E.
Diſtance 880 miles.

M.P.
Madeira's lat. = 32° 38′ N. 2073
Ship's lat. = 38 20 N. 2494
Diff. lat. = 5 52 421
Or = 352 miles.
Madeira's long. = 16° 51′ W.
Ship's long. = 17 18 W.
Diff. long. = 0 27
Madeira bears S 13° 45′ E.
Diſtance 355 miles.

Journal from England towards Madeira.

LOG-BOARD.

H.	K.	F.	Courſes	Winds
2	10	0	S.b.W$\frac{1}{2}$W	Wb.S$\frac{1}{2}$W.
4	9	6	Leeway	1 point
6	10	4		
8	10	0	ESE.	South
10	10	5	Leeway	1 point
12	9	8		
2	10	3	S.b.W$\frac{1}{2}$W	ESE.
4	10	6	Leeway	0 point
6	11	7		
8	11	8		
10	11	4	ESE.	NE.
12	11	6	Leeway	1 point

Remarks on board.

☉. 15th October.

Theſe 24 hours very hard gales and variable, with clouds and rain.

Variation 12 degrees weſt.

Intending next day to take an obſervation of the moon's culminating, we this day, before and after noon, took equal altitudes of the ſun, and ſet a good ſecond watch to the true noon.

Obſerv'd ſun's merid. zen. diſt. = 44° 44′ S.
Declination = 9 08 S.
Lat. by obſervation = 35 36 N.

TRAVERSE TABLE.

Courſes	D.	N.	S.	E.	W.
S 6°30′E	60		59,6	6,8	
N89 15 E	61	0,8		61,0	
S. 5 0 E	89		88,7		7,8
S.68 15 E	46		17,0	42,7	
		0,8	165,3	110,5	7,8
			0,8	7,8	
		D. l.	164,5	102,7	Dep.

Dep. lat. = 38° 20′ N.
Diff. lat. = 2 44 S.
Pref. lat. = 35 36 N.
Sum lats. = 73 56
Middle lat. = 36 58
Dep. long. = 17 18 W.
Diff. long. = 2 08 E.
Pref. long. = 15 10 W.

Here the lat. as by account agrees with the lat. by obſervation. Therefore the diff. long. is found with the dep. by account.

		M. P.
Lizard's lat.	= 49° 57′ N.	3470
Ship's lat.	= 35 36 N.	2288
Diff. lat.	= 14 21	1182
Or	= 861 miles.	
Lizard's long.	= 5° 14′ W.	
Ship's long.	= 15 10 W.	
Diff. long.	= 9 56 = 596 m.	

Lizard bears N. 26° 45′ E.
Diſtance 965 miles.

		M. P.
Madeira's lat.	= 32° 38′ N.	2073
Ship's lat.	= 35 36 N.	2288
Diff. lat.	= 2 58	215
Or	= 178 miles.	
Madeira's lon.	= 16° 51′ W.	
Ship's longit.	= 15 10 W.	
Diff. longit.	= 1 41 = 101 m.	

Madeira bears S. 25° W.
Diſtance 197 miles.

Journal from England towards Madeira.

Log-board.

H.	K.	F.	Courſes	Winds
2	8	6	S.b.W$\frac{1}{2}$W	W.b.S$\frac{1}{2}$W
4	9	0	Leeway	1 point
6	9	0		
8	8	5		
10	9	0	W. b. S.	North
12	8	6	Leeway	0 point
2	8	5		
4	9	2		
6	8	4	S.b.W$\frac{3}{4}$W	W. b. S.
8	7	6	Leeway	1 point
10	6	2		
12	5	6		

Traverse Table.

Courſes	D.	N.	S.	E.	W.
S. $\frac{1}{2}$ E.	70		69,7	6,9	
WSW.	71		27,2		65,6
S. $\frac{1}{4}$ E.	55		54,9	2,7	
			151,8	9,6	65,6
					9,6
					56,0

Remarks on board.

☽. 16th October.

Theſe 24 hours ſtiff gales, cloudy and variable winds.

Variation 1 point weſt.

Out 1ſt and 2d reef of both top ſails.

At 7 h. 15 m. 2$\frac{1}{2}$ ſ. P. M. the moon's centre paſſed the meridian.

At 8 A. M. Iſle Porto ſancto bore SE., diſt. 10 leagues. And Madeira bore SSW. $\frac{3}{4}$W., diſt. 15 leagues.

Obſerved ſun's mer. zen. diſt.	42° 20′ S.
Declination	9 30 S.
Lat. by obſervation	32 50 N.
Depart. lat.	35 36
Diff. lat.	2 46
Or 166 miles.	

By my Ephemeris, the moon paſſed the meridian of London at 7 h. 13 m. P. M. which is 2 m. 2$\frac{1}{2}$ ſ. before the obſerved time.

Now by the Ephemeris the moon's daily diff. is 45 min.

Then by art. 1123,

As 45 min. : 2 min. 2$\frac{1}{2}$ ſec. : : 360° : 16° 18′, the diff. long.

Dep. lat. = 35° 36′ N.
Diff. lat. = 2 32 S.
Lat. by account = 33 04 N.
Lat. by obſervation = 32 50 N.
Sum lats. = 68 26
Mid. lat. = 34 13
Dep. long. = 15 10 W.
Diff. long. = 1 15 W.
Pref. long. = 10 30 W.

The lat. by account falling ſhort of the true lat. by 14 m., and the diff. lat. being above twice the dep., the correction at art. 1112 is to be uſed.

To diff. lat. 151,8 and dep. 56, the courſe is 20 deg. 30 min.: With 20 deg. 30 min. and true diff. lat. 166, the true dep. is 62.

With which find the diff. longitude.

The long. by acct. nearly agrees with the long. found by obſervation.

			M. P.
Lizard's lat.	=	49° 57′ N.	3470
Ship's lat.	=	32 50 N.	2088
Diff. lat.	=	17 07	1382
Or	=	1027 miles.	
Lizard's long.	=	5° 14′ W.	
Ship's long.	=	16 18 W.	
Diff. long.	=	11 04 W. = 664 m.	

Lizard bears N. 25° 30′ E.
Diſtance 1140 miles.

			M. P.
Fonchal's lat.	=	32° 38′ N.	207
Ship's lat.	=	32 50 N.	2088
Diff. lat.	=	0 12	1
Or	=	12 miles.	
Fonchal's lon.	=	16° 51′ W.	
Ship's long.	=	16 18 W.	
Diff. long.	=	0 33 miles.	

Fonchal bears S. 65° 15′ W.
Diſtance 29 miles.

SECT

SECTION XI.

Of the ſurveying of Coaſts and Harbours.

From what has been already ſaid in the latter ſections of Plane ſailing, an intelligent reader would ſee how the buſineſs of taking the bearings of part of a coaſt, and of plotting or delineating it, might be done: But as there are ſome particulars which can be gained only by experience in the art of ſurveying, it will not be improper to apprize the learner concerning them, and thereby qualify him to go more readily to work.

1137. *To take the draught of a coaſt in ſailing along it.*

1ſt. Having brought the ſhip to a convenient place, from whence the principal points of the coaſt or bay may be ſeen, either caſt anchor if 'tis convenient, or *lye to* as ſteady as poſſible; or if the coaſt is too ſhoal, let the obſervations and meaſures be done in a boat: Then while the veſſel is in a ſtationary ſituation, take with the azimuth compaſs the bearings of ſuch points of the coaſt as form the moſt material projections or hollows; write down theſe bearings, and make a rough ſketch of the appearance of the coaſt, obſerving carefully to mark the points whoſe bearings were taken.

2d. Then let the ſhip or boat run in a direct line one, two, or three miles, more or leſs, until ſhe comes into a ſituation from whence the ſame points before obſerved can be ſeen again; there let the veſſel lye ſteady as at the foregoing ſtation, and again obſerve the reſpective bearings of the ſame noted points, which are alſo to be wrote down, and a rough ſketch of the coaſt ſhould alſo be taken from this ſtation: But while the veſſel is running the *baſe line* from ſtation to ſtation, a more accurate drawing of the appearance of the coaſt ſhould be made.

3d. *To map theſe obſervations.* In ſome convenient part of a ſheet of paper deſcribe a circle (the larger the better), on which lay the ſeveral bearings taken from the firſt ſtation, and let them be numbered 1, 2, 3, *&c.* on the outſide of the circle: Alſo lay down the ſeveral bearings taken from the ſecond ſtation, let theſe be numbered 1, 2, 3, *&c.* on the inſide of the circle, obſerving that the bearings of the ſame points are numbered with the ſame figures.

4th. Draw a line to expreſs the ſhip's run both in length and courſe; and from that end of the line expreſſing the firſt ſtation, draw lines parallel to the reſpective bearings taken from that end, and marked on the outſide of the circle: Alſo from the other end, draw lines parallel to the bearings taken at that end, and noted on the inſide of the circle; mark the interſection of each pair of lines, directed to the ſame point, with the number annexed to their bearing; and thro' the interſections ſo marked, draw by hand a curved line, obſerving to wave the line in and out, as near as can be like the trending of the coaſt itſelf.

5th. Againſt each part, draw the appearance of the elevated or low ground as marked in the ſketches, diſtinguiſhing rocks, cliffs, high-land, low-land, ſand hills, *&c.* If there are any currents or eddies, expreſs them in their proper places by darts, the points being turned that way the curent ſets: Put in the ſeveral ſoundings at low water in ſmall figures, diſtinguiſhing whether fathoms or feet; ſhew the time of high water on the full and change days by roman figures, and tell the riſe in feet: Put in a compaſs corrected by the variation, with a ſcale of miles or leagues, ſuch as the veſſel's run was laid down by.

6th. If there is a ſhoal or ſand on the coaſt, let it be taken by a boat ſailing round it, and keeping an account of the courſes, diſtances and ſoundings: But to put it in the draught, the boat muſt from ſome part of the ſand or ſhoal, take the bearings of two points on the coaſt, whoſe bearings have been taken from the ſhip: Or, the bearing of the boat at ſome part of the ſhoal, or of ſome beacon in that place, muſt be taken by the ſhip at the ſtations where ſhe takes the bearings of the ſhore; for by either of theſe means, one point of the ſand being obtained, the reſt of it can be laid down from the boat's account.

7th. If the coaſt to be drawn is a bay or harbour, winding in ſuch a manner that all its principal points cannot be ſeen at two ſtations, let as many baſes or lines be run and exactly meaſured as may be found neceſſary; obſerving that the ſeveral diſtances run ſhould join to one another in the nature of a traverſe, that each new ſet of objects or points obſerved, ſhould be taken from two ſtations at the ends of a known diſtance, and that the objects, whoſe bearings are taken, do not extend ſo much beyond the limits of the baſe, as to make angles with it of leſs than about ½ or ¾ of a point; but rather reſerve ſuch objects for the next meaſured baſe; for when lines lie very oblique to one another, their interſection is not eaſily aſcertained.

8th. If any particular parts of the harbour cannot be conveniently ſeen from either of the ſtations, take the boat into thoſe places, and having well examined them, make ſketches thereof, eſtimating the lengths and breadths of the ſeveral inlets either by the rowing or ſailing of the boat, taking as many bearings, ſoundings and other notes, as may be thought neceſſary; then annex theſe particular views in their proper places in the general draught.

9th. If there are any dangerous ſands or rocks, beſides inſerting them in their proper places, there ſhould be a double line drawn thro' that point and one or more objects aſhore; and for this purpoſe, chuſe a church, mill, houſe, noted tree, a cliff, or any other remarkable thing that can be diſtinctly ſeen at ſea, and which can be brought to bear in the ſame right line with the point to be avoided: But if that point is under water, there muſt be two land marks brought to bear with the danger, either in the ſame right line when it can be, or in two lines; and that thoſe land-marks may be put down in their proper places, their bearings muſt alſo be taken from two of the ſhip's ſtations.

10th. It ſhould be remarked in the draught what places, if any, are unfit for anchorage, and what are fit, by writing *rocky ground*, *foul anchorage*, *good anchorage*; and in the latter to draw the figure of an anchor: Alſo, if there is any particular channel more convenient to ſail thro' than another, it is to be pointed out by lines drawn to its entrance from two or more noted marks aſhore.

The foregoing method of ſurveying a coaſt, ſuppoſes in general that it is taken by a ſhip in her paſſing along, not having an opportunity of going aſhore: But when the circumſtances will permit the meaſures and obſervations to be made on land, the ſurvey can be taken more accurately than on the water.

1138. *To ſurvey a harbour by obſervations on ſhore.*

1ſt. Go round the place to be ſurveyed, and in the moſt remarkable points and bends of the ſhore fix ſtation ſtaves, or ſtrait poles, tall enough to be ſeen at a conſiderable diſtance; but if at any of thoſe places there is a noted tree, houſe, or any other remarkable thing, that object may ſerve inſtead of a ſtation ſtaff; and it will be convenient to black the ſtaves, and tie a piece of white bunting to the top of each.

2d. Chuſe a ſpot of level ground, on which meaſure, for a baſe, a length of half a mile, or a mile if convenient, obſerving that the direction of the meaſured line be ſo laid out, that from both ends of it all the ſtation ſtaves before planted, or the objects before remarked, may be ſeen.

3d. From one end of the baſe, obſerve (with any inſtrument proper to take bearings) the poſitions or bearings of all the ſtaves or objects, and write them down orderly; do the ſame from the other end of the baſe.

4th. Then theſe meaſures being plotted or laid down, will give the moſt conſpicuous points of the ſhore; the intermediate ſpaces are to be filled up from the ſketches of them made on the ſpot, as in 8th of art. 1137.

5th. But if any of theſe objects ſhould ſpread on either hand ſo far beyond the limits of the baſe, that at either end thereof, the other end and thoſe objects or ſtaves ſhould appear nearly in the ſame direction, or to make angles not exceeding about 10 degrees; then it will be proper to chuſe another level place, on which a baſe may be meaſured like the former, and from the extremities of which, the ends of the firſt baſe may be ſeen, and alſo the remaining objects or ſtaves which were too oblique for the firſt baſe: And proceed in like manner to a 3d, 4th, &c. baſe if neceſſary. The reſt like the directions in art. 1137.

Sea draughts taken according to theſe precepts, and neatly drawn, beſides the real uſe they may be of, can't fail to recommend the young mariner, who ſurveys and conſtructs them, to the notice of his ſuperiors.

SECTION XII.

To eſtimate diſtances.

Beſides the method of finding the diſtances of remote objects by trigonometrical computations, there are two other means which may be uſefully applied when the former cannot; and theſe are, the *motion of ſound*, and the *curvature of the earth*.

1139. *Of the motion of ſound.*

It is a well known obſervation, that the noiſe or ſound ariſing from any blow or ſhock made at a diſtance, is always heard ſome time after the ſtroke is ſeen, or known to be given; and hence it is generally concluded that the ſeeing of any act done within view is inſtantaneous, but that ſound travels at a perceptible rate.

Some of the moſt eminent philoſophers, judging that the knowledge of the flight of ſound might be of uſe on various occaſions, have been at extraordinary pains and expence to meaſure the rate at which it moved, and the reſult of their experiments, particularly of thoſe which were beſt conducted, are as follows.

1ſt. The velocity of ſound is the ſame whether, by ſea or by land, in dry or in rainy weather, by day or by night, in winter or ſummer.

2d. That ſound, whether more or leſs ſtrong, flies with the ſame ſwiftneſs: For by experiments, a cannon fired with a half pound charge of powder was heard at about the diſtance of 17$\frac{1}{2}$ miles in the ſame time after the flaſh was ſeen, as when fired with a charge of 6 lb.

3d. That the times in which ſound is heard is proportional to the diſtance; that is, at a double diſtance it is heard in twice the time, at a triple diſtance in thrice the time, *&c.*

4th. That ſound flies quicker or ſlower, by juſt as much as is the velocity of the wind, according as it is with or againſt the motion of the ſound.

5th. That ſound travels at the rate of about 1142 feet, or 380 yards in one ſecond of time; ſo that

Sound moves in 1 ſecond 1142 feet, or 380 yards.
in 1 minute 22840 yards, or about 13 miles.
Which is about a mile in 4,6 ſeconds, or about a league in 14 ſeconds.

But ſea miles are to land miles, nearly as 7 to 6. (900)

Therefore ſound runs a ſea league in about 12 ſeconds of time.

It is a common obſervation, that perſons in good health have about 75 pulſations or beats of the artery at the wriſt in a minute.

1140. Therefore in 75 pulſations, ſound flies about 13 land miles, and about 11$\frac{1}{7}$ ſea miles; which is about 1 land mile in 6 pulſes, and about 1 ſea mile in near 7 pulſes, or a league in 20 pulſes.

And hence the diſtance of objects may be found by knowing the time which ſound takes to move from thoſe objects to an obſerver.

Example. *Upon ſeeing the flaſh of a gun at ſea, I counted* 56 *beats of the pulſe at the wriſt before I heard the report: How far was that gun from me?*

Now 56 divided by 20 gives 2,8 leagues, or about 8 miles.

1141. *Of the curvature of the earth.*

Moſt perſons know that if they are raiſed above the ſurface of the adjacent land or water, they can not only ſee diſtant objects that lie on that ſurface better, but alſo ſee thoſe more and more remote as they advance higher. The irregularity of the ſurface of the land will not be ſubjected to any one rule that will give the diſtance to which objects may be ſeen at different elevations; but at ſea, where there is generally an uniform curvature of the ſurface of the water, upon the ſuppoſition of the ſpherical figure of the earth, thoſe diſtances may be eaſily computed.

1142. Let (ſee fig. 12. Pl. XI.) the eye at E be raiſed the height ES above the ſurface S of the water; then will it ſee an object at f on the ſurface, in the tangent Ef, which is the diſtance of that object from the eye.

Now in the triangle EfC, right angled at f, there are known, the ſide Cf = ſemidiameter of the earth, and the ſide CE equal to the ſemidiameter CS increaſed by SE the height of the eye: To find the tangent Ef.

Then by art. 203. $\text{E}f = \sqrt{\overline{\text{CE}}^2 - \overline{\text{C}f}^2} = \sqrt{\overline{\text{CS} + \text{SE}}^2 - \overline{\text{C}f}^2} = \sqrt{\overline{2\,\text{CS} + \text{SE}} \times \text{SE}}$.

That is, *To the earth's diameter add the height of the eye, multiply the ſum by that height; then the ſquare root of the product is the diſtance at which an object on the ſurface of the water can be ſeen by an eye ſo elevated.*

And by this rule was the table at art. 1145 computed, the diameter of the earth being taken at 41798117 feet, according to Sir Iſaac Newton's meaſures.

This table may be uſefully applied to eſtimate the diſtance of an object at ſea, the elevation of that object above its horizon being known.

Example I. *Sailing towards a headland on which is a lighthouſe elevated* 600 *feet above the ſurface of the water, we ſaw the lights at night juſt appearing in the horizon: How far were we at that time diſtant from the lighthouſe?*

Seek in the table at article 1145 for 600 feet in the column ſigned *height in feet*, and right againſt it in the column ſigned *diſtance in miles*, ſtands 29,994; ſo that the diſtance may be reckoned about 30 miles.

Example II. *Being in company with ſome merchants walking on a ſandy ſhore on the look out for a veſſel which was then expected, whoſe top-gallant maſt was* 140 *feet above the ſurface, allowance being made for her immerſion in the water; we obſerved thro' a teleſcope a ſhip's vane juſt appearing in the horizon: How far off is that ſhip, ſuppoſing it the veſſel expected?*

Answer. Againſt 140 feet, the height, ſtands 14,488; that is, her diſtance is about 14½ miles.

1143. Here is no allowance made for the height of the eye above the horizon; but it is obvious, that the higher the eye, the farther it can ſee: Now as objects are ſeen in a ſtrait line, and that line is a tangent to the earth's ſurface; therefore it follows, that *to find the diſtance of two elevated objects when the right line joining them touches the ſurface of the earth between thoſe objects; Seek the diſtance anſwering to each height, and their ſum is the diſtance ſought.*

Thus in example II. ſuppoſe the eye is raiſed 6 feet above the water's edge, it can ſee an object on the ſurface 2,999, or 3 miles off; this diſtance added to the 14½ miles, makes the diſtance of the ſhip to be 17½ miles.

Example III. *A man being on the main-top gallant maſt of a man of war,* 200 *feet above the water, ſees a* 100 *gun ſhip ſhe had engaged the day before,* hull to: *How far were thoſe ſhips diſtant?*

A ſhip of 100 guns, or a firſt rate man of war, is about 60 feet from the keel to the rails; from which deduct about 20 feet for the draught of water, leaves 40 feet for the height of her quarter above water: Now a ſhip is ſeen *hull to*, when her upper-works juſt diſappear.

Then 200 feet high, gives 17,316 miles.
And againſt 40 feet ſtands 7,714 miles.

Their ſum, which is 25,030 miles, is their diſtance.

1144. It might perhaps hereafter be found uſeful to mariners, could a liſt of the moſt conſiderable lighthouſes, and other elevated objects in different parts of the world, be obtained; together with their heights above the water: For as ſome of theſe objects are ſo high as to be ſeen at the diſtance of 30 or 40 miles, and even more; and as their diſtances upon being firſt ſeen could be near enough known by the table at art. 1145, were their heights known; therefore ſuch a liſt might on ſeveral occaſions not only give much ſatisfaction to a ſeaman, but even become of great uſe to know his diſtance from thoſe objects, as he could thereby know how to increaſe or ſlacken ſail in order to ſave his tide, or other emergency; alſo he would know better how to lay down the diſtances of rocks or ſhoals that lie off a coaſt, &c. But as ſuch a liſt is not eaſy to be come at, unleſs ſkilful mariners would be at the trouble of procuring ſuch as occurred to them in their voyages, and on their return communicate them to ſome public body; therefore the curious in thoſe matters muſt be contented at preſent with what is here already ſaid.

Art. 1145. *A* TABLE *for finding the diſtance of obſerved terreſtrial objects at ſea.*

Height in feet	Diſt. in miles	Height in feet	Diſt. in miles	Height in feet	Diſt. in miles	Height in feet	Diſt. in miles	Height in feet	Diſt. in miles
1	1,224	53	8,914	240	18,969	760	33,756	2250	58,083
2	1,732	56	9,163	245	19,165	780	34,197	2300	58,725
3	2,121	59	9,405	250	19,360	800	34,633	2350	59,360
4	2,449	62	9,641	255	19,553	820	35,063	2400	59,988
5	2,738	65	9.872	260	19,743	840	35,488	2450	60,609
6	2,999	68	10,097	265	19,932	860	35,908	2500	61,225
7	3,239	71	10,317	270	20,119	880	36,323	2550	61,834
8	3,463	74	10,533	275	20,305	900	36,734	2600	62,437
9	3,673	77	10,745	280	20,489	920	37,140	2650	63,035
10	3,872	80	10,952	285	20,671	940	37,541	2700	63,626
11	4,061	83	11,156	290	20,851	960	37,938	2750	64,213
12	4,242	86	11,355	295	21,030	980	38,332	2800	64,794
13	4,415	89	11,552	300	21,208	1000	38,721	2850	65,370
14	4,581	92	11,745	310	21,558	1030	39,297	2900	65,941
15	4,742	95	11,935	320	21,903	1060	39,866	2950	66,507
16	4,898	98	12,121	330	22,243	1090	40,426	3000	67,068
17	5,048	101	12,306	340	22,578	1120	40,978	3050	67,625
18	5,195	104	12,487	350	22,907	1150	41,524	3100	68,177
19	5,338	107	12,666	360	23,232	1180	42,062	3150	68,725
20	5,476	110	12,842	370	23,553	1210	42,593	3200	69,268
21	5,611	113	13,016	380	23,869	1240	43,118	3250	69,807
22	5,743	116	13,188	390	24,181	1270	43,636	3300	70,342
23	5,872	119	13,357	400	24,489	1300	44,149	3350	70,873
24	5,999	122	13,525	410	24,793	1330	44,655	3400	71,400
25	6,122	125	13,690	420	25,094	1360	45,156	3450	71,923
26	6,243	128	13,853	430	25,391	1390	45,651	3500	72,443
27	6,362	131	14,015	440	25,684	1420	46,141	3550	72,958
28	6,479	134	14,174	450	25,974	1450	46,629	3600	73,470
29	6,594	137	14,332	460	26,261	1480	47,106	3650	73,979
30	6,709	140	14,488	470	26,545	1510	47,581	3700	74,484
31	6,817	143	14,642	480	26,826	1540	48,052	3750	74,985
32	6,928	146	14,795	490	27,104	1570	48,517	3800	75,484
33	7,034	150	14,995	500	27,379	1600	48,979	3850	75,979
34	7,140	155	15,244	510	27,652	1630	49,436	3900	76,471
35	7,244	160	15,488	520	27,922	1660	49,889	3950	76,959
36	7,347	165	15,728	530	28,189	1690	50,338	4000	77,445
37	7,448	170	15,965	540	28,454	1720	50,782	4050	77,927
38	7,548	175	16,198	550	28,716	1750	51,223	4100	78,407
39	7,647	180	16,427	560	28,976	1780	51,661	4150	78,884
40	7,744	185	16,654	570	29,233	1810	52,094	4200	79,358
41	7,840	190	16,878	580	29,489	1840	52,524	4250	79,829
42	7,935	195	17,098	590	29,742	1870	52,951	4300	80,297
43	8,029	200	17,316	600	29,994	1900	53,374	4350	80,762
44	8,122	205	17,531	620	30,489	1930	53,793	4400	81,225
45	8,214	210	17,744	640	30,976	1960	54,210	4450	81,685
46	8,305	215	17,955	660	31,457	2000	54,761	4500	82,143
47	8,394	220	18,162	680	31,930	2050	55,441	4550	82,598
48	8,483	225	18,366	700	32,396	2100	56,113	4600	83,051
49	8,570	230	18,569	720	32,855	2150	56,777	4650	83,501
50	8,658	235	18,770	740	33,309	2200	57,434	4700	83,949

Remarks on the uſe of the following Tables.

1146. Thoſe who require no greater accuracy in the operations than to aſſign the diſtances or lengths of lines in whole miles or leagues, and the angles of triangles in points and quarter-points, may be accommodated in the firſt page only of the following logarithmic tables; wherein are two which will ſufficiently anſwer their purpoſe. Indeed it is beſt to uſe the ſecond of theſe tables, whenever the angle is given in points and quarters; for the quarter-points, containing degrees minutes and ſeconds, cannot be accurately found among the common tables of ſines, tangents and ſecants; and therefore was the table at article 1150 added, wherein the log. ſines, tangents and ſecants agree, even to the ſeconds in the quarter points.

1147. In the table of the logarithms of numbers, article 1151, the indices are omitted, becauſe the logarithms ſerve as well for fractional numbers as for integers, as ſhewn in article 84; and the index is eaſily annexed in their uſe by the rule at article 82, obſerving that when whole numbers are uſed, the index of the logarithm is always one leſs than the number of places in that whole number; and that the index of a logarithm increaſed by one, gives the integer places in the correſponding number: So that when theſe tables are uſed, the operator muſt be careful always to annex the index.

1148. In the table, article 1152, there are no ſecants added, becauſe they are not uſed in any part of this work; but thoſe who are deſirous to compute by them, may eaſily ſupply this want, by taking the arithmetical complements (by article 88) of the coſines to the degrees and minutes for which the ſecant is required: The logarithmic ſecants and coſines of the ſame arcs being the arithmetical complements of one another, as ſhewn in article 367.

Articles 1149, 1150, 1151, 1152.

LOGARITHMIC TABLES.

I. The LOGARITHMS of NUMBERS from 1 to 120.

II. The LOGARITHMIC SINES, TANGENTS and SECANTS, to every Point and Quarter-Point of the COMPASS.

III. The LOGARITHMS of NUMBERS from 100 to 10000.

IV. The LOGARITHMS of the SINES and TANGENTS to every Degree and Minute of the QUADRANT.

1149. A TABLE

Of Numbers and their Logarithms from 1 *to* 120.

N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.
1	0,00000	21	1,32222	41	1,61278	61	1,78533	81	1,90848	101	2,00432
2	0,30103	22	1,34242	42	1,62325	62	1,79239	82	1,91381	102	2,00860
3	0,47712	23	1,36173	43	1,63347	63	1,79934	83	1,91908	103	2,01284
4	0,60206	24	1,38021	44	1,64345	64	1,80618	84	1,92428	104	2,01703
5	0,69897	25	1,39794	45	1,65321	65	1,81291	85	1,92942	105	2,02119
6	0,77815	26	1,41497	46	1,66276	66	1,81954	86	1,93450	106	2,02531
7	0,84510	27	1,43136	47	1,67210	67	1,82607	87	1,93952	107	2,02938
8	0,90309	28	1,44716	48	1,68124	68	1,83251	88	1,94448	108	2,03342
9	0,95424	29	1,46240	49	1,69020	69	1,83885	89	1,94939	109	2,03743
10	1,00000	30	1,47712	50	1,69897	70	1,84510	90	1,95424	110	2,04139
11	1,04139	31	1,49136	51	1,70757	71	1,85126	91	1,95904	111	2,04532
12	1,07918	32	1,50515	52	1,71600	72	1,85733	92	1,96379	112	2,04922
13	1,11394	33	1,51851	53	1,72428	73	1,86332	93	1,96848	113	2,05308
14	1,14613	34	1,53148	54	1,73239	74	1,86923	94	1,97313	114	2,05690
15	1,17609	35	1,54407	55	1,74036	75	1,87506	95	1,97772	115	2,06070
16	1,20412	36	1,55630	56	1,74819	76	1,88081	96	1,98227	116	2,06446
17	1,23045	37	1,56820	57	1,75587	77	1,88649	97	1,98677	117	2,06819
18	1,25527	38	1,57978	58	1,76343	78	1,89209	98	1,99123	118	2,07188
19	1,27875	39	1,59106	59	1,77085	79	1,89763	99	1,99563	119	2,07555
20	1,30103	40	1,60206	60	1,77815	80	1,90309	100	2,00000	120	2,07918

1150. A TABLE

Of Logarithmic Sines, Tangents and Secants, to every Quarter point of the Compaſs.

Pts.	Sines	Co-ſines	Tangents	Co-tang.	Secants	Co-ſecants	
0	0,00000	10,00000	0,00000	Infinite	10,00000	Infinite	8
0¼	8,69079	9,99947	8,69131	11,30867	10,00053	11,30921	7¾
0½	8,99130	9,99790	8,99340	11,00660	10,00210	11,00870	7½
0¾	9,14652	9,99527	9,17124	10,82675	10,00473	10,85348	7¼
1	9,29024	9,99157	9,29866	10,70134	10,00843	10,70976	7
1¼	9,38557	9,98678	9,39878	10,60121	10,01322	10,61443	6¾
1½	9,46282	9,98088	9,48194	10,51806	10,01912	10,53717	6½
1¾	9,52749	9,97384	9,55365	10,44635	10,02616	10,47251	6¼
2	9,58284	9,96562	9,61722	10,38278	10,03438	10,41716	6
2¼	9,63099	9,95616	9,67482	10,32518	10,04384	10,36901	5¾
2½	9,67339	9,94543	9,72796	10,27204	10,05457	10,32661	5½
2¾	9,71104	9,93335	9,77770	10,22230	10,06665	10,28896	5¼
3	9,74474	9,91985	9,82489	10,17511	10,08015	10,25526	5
3¼	9,77503	9,90483	9,87020	10,12980	10,09517	10,22497	4¾
3½	9,80236	9,88819	9,91417	10,08583	10,11181	10,19764	4½
3¾	9,82708	9,86979	9,95729	10,04270	10,13021	10,17292	4¼
4	9,84948	9,84948	10,00000	10,00000	10,15052	10,15052	4
	Co-ſines	Sines	Co-tang.	Tangents	Co-ſecants	Secants	Pts.

Numbers from 100 to 1600. Logs. from ,00000 to ,20412.

N°	0	1	2	3	4	5	6	7	8	9
100	,00000	,00043	,00087	,00130	,00173	,00217	,00261	,00303	,00346	,00389
101	,00432	,00475	,00518	,00561	,00604	,00647	,00689	,00732	,00775	,0 817
102	,00860	,00903	,00945	,00988	,01030	,01072	,01115	,01157	,01199	,01242
103	,01284	,01326	,01368	,01410	,01452	,01494	,01536	,01578	,01620	,01661
104	,01703	,01745	,01787	,01828	,01870	,01912	,01953	,01995	,02036	,02077
105	,02119	,02160	,02202	,02243	,02284	,02325	,02366	,02407	,02449	,02490
106	,02531	,02571	,02612	,02653	,02694	,02735	,02776	,02816	,02857	,02898
107	,02938	,02979	,03019	,03060	,03100	,03141	,03181	,03222	,03262	,03302
108	,03342	,03383	,03423	,03463	,03503	,03543	,03583	,03623	,03663	,03703
109	,03743	,03782	,03822	,03862	,03902	,03941	,03981	,04021	,04060	,04100
110	,04139	,04179	,04218	,04257	,04297	,04336	,04375	,04415	,04454	,04493
111	,04532	,04571	,04610	,04649	,04688	,04727	,04766	,04805	,04844	,04883
112	,04922	,04961	,04999	,05038	,05077	,05115	,05154	,05192	,05231	,05269
113	,05308	,05346	,05385	,05423	,05461	,05500	,05538	,05576	,05614	,05652
114	,05690	,05729	,05767	,05805	,05843	,05880	,05918	,05956	,05994	,06032
115	,06070	,06108	,06145	,06183	,06221	,06258	,06296	,06333	,06371	,06408
116	,06446	,06483	,06521	,06558	,06595	,06633	,06670	,06707	,06744	,06781
117	,06819	,06856	,06893	,06930	,06967	,07004	,07041	,07078	,07114	,07151
118	,07188	,07225	,07262	,07298	,07335	,07372	,07408	,07445	,07482	,07518
119	,07555	,07591	,07628	,07664	,07700	,07737	,07773	,07809	,07846	,07882
120	,07918	,07954	,07990	,08027	,08063	,08099	,08134	,08171	,08207	,08243
121	,08278	,08314	,08350	,08386	,08422	,08458	,08493	,08529	,08565	,08600
122	,08636	,08672	,08707	,08743	,08778	,08814	,08849	,08884	,08920	,08955
123	,08990	,09026	,09061	,09096	,09131	,09167	,09202	,09237	,09272	,09307
124	,09342	,09377	,09412	,09447	,09482	,09517	,09552	,09587	,09621	,09656
125	,09691	,09726	,09760	,09795	,09830	,09864	,09899	,09933	,09968	,10003
126	,10037	,10071	,10106	,10140	,10175	,10209	,10243	,10278	,10312	,10346
127	,10380	,10414	,10449	,10483	,10517	,10 51	,10585	,10619	,10653	,10687
128	,10721	,10755	,10789	,10823	,10856	,10890	,10924	,10958	,10992	,11025
129	,11059	,11093	,11126	,11160	,11193	,11227	,11260	,11294	,11327	,11361
130	,11394	,11428	,11461	,11494	,11528	,11561	,11594	,11628	,11661	,11694
131	,11727	,11760	,11793	,11826	,11859	,11893	,11926	,11959	,11991	,12024
132	,12057	,12090	,12123	,12156	,12189	,12222	,12254	,12287	,12320	,12352
133	,12385	,12418	,12450	,12483	,12516	,12548	,12581	,12613	,12646	,12678
134	,12710	,12743	,12775	,12808	,12840	,12872	,12904	,12937	,12969	,13001
135	,13033	,13065	,13098	,13130	,13162	,13194	,13226	,13258	,13290	,13322
136	,13354	,13386	,13418	,13450	,13481	,13513	,13545	,13577	,13609	,13640
137	,13672	,13704	,13735	,13767	,13799	,13830	,13862	,13893	,13925	,13956
138	,13988	,14019	,14051	,14082	,14114	,14145	,14176	,14208	,14239	,14270
139	,14301	,14333	,14364	,14395	,14426	,14457	,14488	,14520	,14551	,14582
140	,14613	,14644	,14675	,14706	,14737	,14768	,14798	,14829	,14860	,14891
141	,14922	,14953	,14983	,15014	,15045	,15076	,15106	,15137	,15168	,15198
142	,15229	,15259	,15290	,15320	,15351	,15381	,15412	,15442	,15473	,15503
143	,15534	,15564	,15594	,15625	,15655	,15685	,15715	,15746	,15776	,15806
144	,15836	,15866	,15896	,15927	,15957	,15987	,16017	,16047	,16077	,16107
145	,16137	,16167	,16197	,16227	,16256	,16286	,16316	,16346	,16376	,16405
146	,16435	,16465	,16495	,16524	,16554	,16584	,16613	,16643	,16673	,16702
147	,16732	,16761	,16791	,16820	,16850	,16879	,16909	,16938	,16967	,16997
148	,17026	,17055	,17085	,17114	,17143	,17172	,17202	,17231	,17260	,17289
149	,17319	,17348	,17377	,17406	,17435	,17464	,17493	,17522	,17551	,17580
150	,17609	,17638	,17667	,17696	,17725	,17754	,17782	,17811	,17840	,17869
151	,17898	,17926	,17955	,17984	,18013	,18041	,18070	,18099	,18127	,18156
152	,18184	,18213	,18241	,18270	,18298	,18327	,18355	,18384	,18412	,18441
153	,18469	,18497	,18526	,18554	,18583	,18611	,18639	,18667	,18696	,18724
154	,18752	,18780	,18808	,18837	,18865	,18893	,18921	,18949	,18977	,19005
155	,19033	,19061	,19089	,19117	,19145	,19173	,19201	,19229	,19257	,19285
156	,19312	,19340	,19368	,19396	,19424	,19451	,19479	,19507	,19535	,19562
157	,19590	,19618	,19645	,19673	,19700	,19728	,19756	,19783	,19811	,19838
158	,19866	,19893	,19921	,19948	,19975	,20003	,20030	,20058	,20085	,20112
159	,20140	,20167	,20194	,20222	,20249	,20276	,20303	,20330	,20358	,20385
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 1600 to 2200. Logs. from ,20412 to ,34242.

N°	0	1	2	3	4	5	6	7	8	9
160	,20412	,20439	,20466	,20493	,20520	,20547	,20574	,20602	,20629	,20656
161	,20683	,20709	,20736	,20763	,20790	,20817	,20844	,20871	,20898	,20925
162	,20951	,20978	,21005	,21032	,21059	,21085	,21112	,21139	,21165	,21192
163	,21219	,21245	,21272	,21299	,21325	,21352	,21378	,21405	,21431	,21458
164	,21484	,21511	,21537	,21564	,21590	,21617	,21643	,21669	,21696	,21722
165	,21748	,21775	,21801	,21827	,21853	,21880	,21906	,21932	,21958	,21985
166	,22011	,22037	,22063	,22089	,22115	,22141	,22167	,22194	,22220	,22246
167	,22272	,22298	,22324	,22350	,22375	,22401	,22427	,22453	,22479	,22505
168	,22531	,22557	,22583	,22608	,22634	,22660	,22686	,22711	,22737	,22763
169	,22789	,22814	,22840	,22866	22891	,22917	,22943	,22968	,22994	,23019
170	,23045	,23070	,23096	,23121	,23147	,23172	,23198	,23223	,23249	,23274
171	,23300	,23325	,23350	,23376	,23401	,23426	,23452	,23477	,23502	,23528
172	,23553	,23578	,23603	,23628	,23654	,23679	,23704	,23729	,23754	,23779
173	,23805	,23830	,23855	,23880	,23905	,23930	,23955	,23980	,24005	,24030
174	,24055	,24080	,24105	,24130	,24155	,24179	,24204	,24229	,24254	,24279
175	,24304	,24329	,24353	,24378	,24403	,24428	,24452	,24477	,24502	,24527
176	,24551	,24576	,24601	,24625	,24650	,24674	,24699	,24724	,24748	,24773
177	,24797	,24822	,24846	,24871	,24895	,24920	,24944	,24969	,24993	,25018
178	,25042	,25066	,25091	,25115	,25139	,25164	,25188	,25212	,25237	,25261
179	,25285	,25310	,25334	,25358	,25382	,25406	,25431	,25455	,25479	,25503
180	,25527	,25551	,25575	,25600	,25624	,25648	,25672	,25696	,25720	,25744
181	,25768	,25792	,25816	,25840	,25864	,25888	,25912	,25935	,25959	,25983
182	,26007	,26031	,26055	,26079	,26102	,26126	,26150	,26174	,26198	,26221
183	,26245	,26269	,26292	,29316	,26340	,26364	,26387	,26411	,26434	,26458
184	,26482	,26505	,26529	,26552	,26576	,26600	,26623	,26647	,26670	,26694
185	,26717	,26741	,26764	,26787	,26811	,26834	,26858	,26881	,26905	,26928
186	,26951	,26975	,26998	,27021	,27045	,27068	,27091	,27114	,27138	,27161
187	,27184	,27207	,27231	,27254	,27277	,27300	,27323	,27346	,27370	,27393
188	,27416	,27439	,27462	,27485	,27508	,27531	,27554	,27577	,27600	,27623
189	,27646	,27669	,27692	,27715	,27738	,27761	,27784	,27807	,27830	,27852
190	,27875	,27898	,27921	,27944	,27967	,27989	,28012	,28035	,28058	,28081
191	,28103	,28126	,28149	,28171	,28194	,28217	,28239	,28262	,28285	,28307
192	,28330	,28353	,28375	,28398	,28420	,28443	,28466	,28488	,28511	,28533
193	,28556	,28578	,28601	,28623	,28646	,28668	,28690	,28713	,28735	,28758
194	,28780	,28802	,28825	,28847	,28870	,28892	,28914	,28937	,28959	,28981
195	,29003	,29026	,29048	,29070	,29092	,29115	,29137	,29159	,29181	,29203
196	,29226	,29248	,29270	,29292	,29314	,29336	,29358	,29380	,29402	,29425
197	,29447	,29469	,29491	,29513	,29535	,29557	,29579	,29601	,29623	,29645
198	,29666	,29688	,29710	,29732	,29754	,29776	,29798	,29820	,29842	,29863
199	,29885	,29907	,29929	,29951	,29972	,29994	,30016	,30038	,30059	,30081
200	,30103	,30125	,30146	,30168	,30190	,30211	,30233	,30255	,30276	,30298
201	,30320	,30341	,30363	,30384	,30406	,30427	,30449	,30471	,30492	,30514
202	,30535	,30557	,30578	,30600	,30621	,30642	,30664	,30685	,30707	,30728
203	,30750	,30771	,30792	,30814	,30835	,30856	,30878	,30899	,30920	,30942
204	,30963	,30984	,31006	,31027	,31048	,31069	,31091	,31112	,31133	,31154
205	,31175	,31197	,31218	,31239	,31260	,31281	,31302	,31332	,31344	,31366
206	,31387	,31408	,31429	,31450	,31471	,31492	,31513	,31534	,31555	,31576
207	,31597	,31618	,31639	,31660	,31681	,31702	,31723	,31744	,31764	,31785
208	,31806	,31827	,31848	,31869	,31890	,31911	,31931	,31952	,31973	,31994
209	,32015	,32035	,32056	,32077	,32098	,32118	,32139	,32160	,32180	,32201
210	,32222	,32243	,32263	,32284	,32305	,32325	,32346	,32366	,32387	,32408
211	,32428	,32449	,32469	,32490	,32510	,32531	,32552	,32572	,32593	,32613
212	,32634	,32654	,32674	,32695	,32715	,32736	,32756	,32777	,32797	,32818
213	,32838	,32858	,32879	,32899	,32919	,32940	,32960	,32980	,33001	,33021
214	,33041	,33062	,33082	,33102	,33122	,33143	,33163	,33183	,33203	,33224
215	,33244	,33264	,33284	,33304	,33326	,33345	,33365	,33385	,33405	,33425
216	,33445	,33465	,33486	,33506	,33526	,33546	,33566	,33586	,33606	,33626
217	,33646	,33666	,33686	,33706	,33726	,33746	,33766	,33786	,33806	,33826
218	,33846	,33866	,33885	,33905	,33925	,33945	,33965	,33985	,34005	,34025
219	,34044	,34064	,34084	,34104	,34123	,34143	,34163	,34183	,34203	,34222
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 2200 to 2800. Logs. from ,34242 to ,44716.

N°	0	1	2	3	4	5	6	7	8	9
220	,34242	,34262	,34282	,34301	,34321	,34341	,34360	,34380	,34400	,34420
221	,34439	,34459	,34478	,34498	,34518	,34537	,34557	,34577	,34596	,34616
222	,34635	,34655	,34674	,34694	,34713	,34733	,34752	,34772	,34791	,34811
223	,34830	,34850	,34869	,34889	,34908	,34928	,34947	,34966	,34986	,35005
224	,35025	,35044	,35064	,35083	,35102	,35122	,35141	,35160	,35180	,35199
225	,35218	,35237	,35257	,35276	,35295	,35315	,35334	,35353	,35372	,35392
226	,35411	,35430	,35449	,35468	,35488	,35507	,35526	,35545	,35564	,35583
227	,35603	,35622	,35641	,35660	,35679	,35698	,35717	,35736	,35755	,35774
228	,35793	,35812	,35832	,35851	,35870	,35889	,35908	,35927	,35946	,35965
229	,35983	,36002	,36021	,36040	,36059	,36078	,36097	,36116	,36135	,36154
230	,36173	,36192	,36210	,36229	,36248	,36267	,36286	,36305	,36324	,36342
231	,36361	,36380	,36399	,36418	,36436	,36455	,36474	,36492	,36511	,36530
232	,36549	,36567	,36586	,36605	,36624	,36642	,36661	,36680	,36698	,36717
233	,36736	,36754	,36773	,36791	,36810	,36829	,36847	,36866	,36884	,36903
234	,36922	,36940	,36959	,36977	,36996	,37014	,37033	,37051	,37070	,37088
235	,37107	,37125	,37144	,37162	,37181	,37199	,37217	,37236	,37254	,37273
236	,37291	,37320	,37328	,37346	,37365	,37383	,37401	,37420	,37438	,37456
237	,37475	,37493	,37511	,37530	,37548	,37566	,37585	,37603	,37621	,37639
238	,37658	,37676	,37694	,37712	,37731	,37749	,37767	,37785	,37803	,37822
239	,37840	,37858	,37876	,37894	,37912	,37930	,37949	,37967	,37985	,38003
240	,38021	,38039	,38057	,38075	,38093	,38111	,38130	,38148	,38166	,38184
241	,38202	,38220	,38238	,38256	,38274	,38292	,38310	,38328	,38346	,38364
242	,38381	,38399	,38417	,38435	,38453	,38471	,38489	,38507	,38525	,38543
243	,38561	,38578	,38596	,38614	,38632	,38650	,38668	,38685	,38703	,38721
244	,38739	,38757	,38775	,38792	,38810	,38828	,38846	,38863	,38881	,38899
245	,38917	,38934	,38952	,38970	,38987	,39005	,39023	,39040	,39058	,39076
246	,39093	,39111	,39129	,39146	,39164	,39182	,39199	,39217	,39234	,39252
247	,39270	,39287	,39305	,39322	,39340	,39357	,39375	,39392	,39410	,39428
248	,39445	,39463	,39480	,39498	,39515	,39533	,39550	,39568	,39585	,39602
249	,39620	,39637	,39655	,39672	,39690	,39707	,39724	,39742	,39759	,39777
250	,39794	,39811	,39829	,39846	,39863	,39881	,39898	,39915	,39932	,39950
251	,39967	,39985	,40002	,40019	,40036	,40054	,40071	,40088	,40106	,40123
252	,40140	,40157	,40174	,40192	,40209	,40226	,40243	,40260	,40278	,40295
253	,40312	,40329	,40346	,40363	,40381	,40398	,40415	,40432	,40449	,40466
254	,40483	,40500	,40517	,40535	,40552	,40569	,40586	,40603	,40620	,40637
255	,40654	,40671	,40688	,40705	,40722	,40739	,40756	,40773	,40790	,40807
256	,40824	,40841	,40858	,40875	,40892	,40909	,40926	,40943	,40959	,40976
257	,40993	,41010	,41027	,41044	,41061	,41078	,41095	,41111	,41128	,41145
258	,41162	,41179	,41196	,41212	,41229	,41246	,41263	,41280	,41296	,41313
259	,41330	,41347	,41363	,41380	,41397	,41414	,41430	,41447	,41464	,41481
260	,41497	,41514	,41531	,41547	,41564	,41581	,41597	,41614	,41631	,41647
261	,41664	,41681	,41697	,41714	,41731	,41747	,41764	,41780	,41797	,41813
262	,41830	,41847	,41863	,41880	,41896	,41913	,41929	,41946	,41962	,41979
263	,41996	,42012	,42029	,42045	,42062	,42078	,42094	,42111	,42127	,42144
264	,42160	,42177	,42193	,42220	,42226	,42243	,42259	,42275	,42292	,42308
265	,42325	,42341	,42357	,42374	,42390	,42406	,42423	,42439	,42455	,42472
266	,42488	,42504	,42521	,42537	,42553	,42570	,42586	,42602	,42619	,42635
267	,42651	,42667	,42684	,42700	,42716	,42732	,42749	,42765	,42781	,42797
268	,42813	,42830	,42846	,42862	,42878	,42894	,42911	,42927	,42943	,42959
269	,42975	,42991	,43007	,43024	,43040	,43056	,43072	,43088	,43104	,43120
270	,43136	,43152	,43168	,43185	,43201	,43217	,43233	,43249	,43265	,43281
271	,43296	,43313	,43329	,43345	,43361	,43377	,43393	,43409	,43425	,43441
272	,43457	,43473	,43489	,43505	,43521	,43537	,43553	,43568	,43584	,43600
273	,43616	,43632	,43648	,43664	,43680	,43696	,43712	,43727	,43743	,43759
274	,43775	,43791	,43807	,43823	,43838	,43854	,43870	,43886	,43902	,43917
275	,43933	,43949	,43965	,43981	,43996	,44012	,44028	,44044	,44059	,44075
276	,44091	,44107	,44122	,44138	,44154	,44169	,44185	,44201	,44217	,44232
277	,44248	,44264	,44279	,44295	,44311	,44326	,44342	,44358	,44373	,44389
278	,44404	,44420	,44436	,44451	,44467	,44482	,44498	,44514	,44529	,44545
279	,44560	,44576	,44591	,44607	,44623	,44638	,44654	,44669	,44685	,44700
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 2800 to 3400. Logs. from ,44716 to ,53148.

N°	0	1	2	3	4	5	6	7	8	9
280	,44716	,44731	,44747	,44762	,44778	,44793	,44809	,44824	,44840	,44855
281	,44871	,44886	,44901	,44917	,44932	,44948	,44963	,44979	,44994	,45009
282	,45025	,45040	,45056	,45071	,45086	,45102	,45117	,45132	,45148	,45163
283	,45179	,45194	,45209	,45225	,45240	,45255	,45271	,45286	,45301	,45316
284	,45332	,45347	,45362	,45378	,45393	,45408	,45423	,45439	,45454	,45469
285	,45484	,45500	,45515	,45530	,45545	,45561	,45576	,45591	,45606	,45621
286	,45637	,45652	,45667	,45682	,45697	,45712	,45728	,45743	,45758	,45773
287	,45788	,45803	,45818	,45834	,45849	,45864	,45879	,45894	,45909	,45924
288	,45939	,45954	,45969	,45984	,45999	,46015	,46030	,46045	,46060	,46075
289	,46090	,46105	,46120	,46135	,46150	,46165	,46180	,46195	,46210	,46225
290	,46240	,46255	,46270	,46285	,46300	,46315	,46329	,46344	,46359	,46374
291	,46389	,46404	,46419	,46434	,46449	,46464	,46479	,46494	,46508	,46523
292	,46538	,46553	,46568	,46583	,46598	,46612	,46627	,46642	,46657	,46672
293	,46687	,46702	,46716	,46731	,46746	,46761	,46776	,46790	,46805	,46820
294	,46835	,46849	,46864	,46879	,46894	,46908	,46923	,46938	,46953	,46967
295	,46982	,46997	,47012	,47026	,47041	,47056	,47070	,47085	,47100	,47114
296	,47129	,47144	,47158	,47173	,47188	,47202	,47217	,47232	,47246	,47261
297	,47276	,47290	,47305	,47319	,47334	,47349	,47363	,47378	,47392	,47407
298	,47422	,47436	,47451	,47465	,47480	,47494	,47508	,47523	,47538	,47553
299	,47567	,47582	,47596	,47611	,47625	,47640	,47654	,47669	,47683	,47698
300	,47712	,47727	,47741	,47755	,47770	,47784	,47799	,47813	,47828	,47842
301	,47857	,47871	,47885	,47900	,47914	,47929	,47943	,47957	,47972	,47986
302	,48001	,48015	,48029	,48044	,48058	,48072	,48087	,48101	,48116	,48130
303	,48144	,48159	,48173	,48187	,48202	,48216	,48230	,48244	,48259	,48273
304	,48287	,48302	,48316	,48330	,48344	,48359	,48372	,48387	,48401	,48416
305	,48430	,48444	,48458	,48473	,48487	,48501	,48515	,48529	,48544	,48558
306	,48572	,48586	,48600	,48615	,48629	,48643	,48657	,48671	,48685	,48700
307	,48714	,48728	,48742	,48756	,48770	,48784	,48799	,48813	,48827	,48841
308	,48855	,48869	,48883	,48897	,48911	,48925	,48940	,48954	,48968	,48982
309	,48996	,49010	,49024	,49038	,49052	,49066	,49080	,49094	,49108	,49122
310	,49136	,49150	,49164	,49178	,49192	,49206	,49220	,49234	,49248	,49262
311	,49276	,49290	,49304	,49318	,49332	,49346	,49360	,49374	,49388	,49401
312	,49415	,49429	,49443	,49457	,49471	,49485	,49499	,49513	,49527	,49541
313	,49554	,49568	,49582	,49596	,49610	,49624	,49638	,49651	,49665	,49679
314	,49693	,49707	,49721	,49734	,49748	,49762	,49776	,49790	,49803	,49817
315	,49831	,49845	,49859	,49872	,49886	,49900	,49914	,49927	,49941	,49955
316	,49969	,49982	,49996	,50010	,50024	,50037	,50051	,50065	,50078	,50092
317	,50106	,50120	,50133	,50147	,50161	,50174	,50188	,50202	,50215	,50229
318	,50243	,50256	,50270	,50284	,50297	,50311	,50325	,50338	,50352	,50365
319	,50379	,50393	,50406	,50420	,50433	,50447	,50461	,50474	,50488	,50501
320	,50515	,50529	,50542	,50556	,50569	,50583	,50596	,50610	,50623	,50637
321	,50650	,50664	,50677	,50691	,50705	,50718	,50732	,50745	,50759	,50772
322	,50786	,50799	,50812	,50826	,50839	,50851	,50866	,50880	,50893	,50907
323	,50920	,50934	,50947	,50961	,50974	,50987	,51001	,51014	,51028	,51041
324	,51054	,51068	,51081	,51095	,51108	,51121	,51135	,51148	,51162	,51175
325	,51188	,51202	,51215	,51228	,51242	,51255	,51268	,51282	,51295	,51308
326	,51322	,51335	,51348	,51362	,51375	,51388	,51402	,51415	,51428	,51441
327	,51455	,51468	,51481	,51495	,51508	,51521	,51534	,51548	,51561	,51574
328	,51587	,51601	,51614	,51627	,51640	,51653	,51667	,51680	,51693	,51706
329	,51720	,51733	,51746	,51759	,51772	,51785	,51799	,51812	,51825	,51838
330	,51851	,51864	,51878	,51891	,51904	,51917	,51930	,51943	,51956	,51970
331	,51983	,51996	,52009	,52022	,52035	,52048	,52061	,52074	,52088	,52101
332	,52114	,52127	,52140	,52153	,52166	,52179	,52192	,52205	,52218	,52231
333	,52244	,52257	,52270	,52283	,52297	,52310	,52323	,52336	,52349	,52362
334	,52375	,52388	,52401	,52414	,52427	,52440	,52453	,52466	,52478	,52491
335	,52504	,52517	,52530	,52543	,52556	,52569	,52582	,52595	,52608	,52621
336	,52634	,52647	,52660	,52673	,52686	,52698	,52711	,52724	,52737	,52750
337	,52763	,52776	,52789	,52802	,52814	,52827	,52840	,52853	,52866	,52879
338	,52892	,52904	,52917	,52930	,52943	,52956	,52969	,52981	,52994	,53007
339	,53020	,53033	,53042	,53058	,53071	,53084	,53097	,53109	,53122	,53135
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 3400 to 4000. Logs. from ,53148 to ,60206.

N°	0	1	2	3	4	5	6	7	8	9
340	,53148	,53161	,53173	,53186	,53199	,53212	,53224	,53237	,53250	,53263
341	,53275	,53288	,53301	,53314	,53326	,53339	,53352	,53364	,53377	,53390
342	,53403	,53415	,53428	,53441	,53453	,53466	,53479	,53491	,53504	,53517
343	,53529	,53542	,53555	,53567	,53580	,53593	,53605	,53618	,53631	,53643
344	,53656	,53668	,53681	,53694	,53706	,53719	,53731	,53744	,53757	,53769
345	,53782	,53794	,53807	,53820	,53832	,53845	,53857	,53870	,53882	,53895
346	,53908	,53920	,53933	,53945	,53958	,53970	,53983	,53995	,54008	,54020
347	,54033	,54045	,54058	,54070	,54083	,54095	,54108	,54120	,54133	,54145
348	,54158	,54170	,54183	,54195	,54208	,54220	,54233	,54245	,54258	,54270
349	,54282	,54295	,54307	,54320	,54332	,54345	,54357	,54370	,54382	,54394
350	,54407	,54419	,54432	,54444	,54456	,54469	,54481	,54494	,54506	,54518
351	,54531	,54543	,54555	,54568	,54580	,54592	,54605	,54617	,54630	,54642
352	,54654	,54667	,54679	,54691	,54704	,54716	,54728	,54740	,54753	,54765
353	,54777	,54790	,54802	,54814	,54827	,54839	,54851	,54863	,54876	,54888
354	,54900	,54913	,54925	,54937	,54949	,54962	,54974	,54986	,54998	,55011
355	,55023	,55035	,55047	,55059	,55072	,55084	,55096	,55108	,55121	,55133
356	,55145	,55157	,55169	,55182	,55194	,55206	,55218	,55230	,55242	,55255
357	,55267	,55279	,55291	,55303	,55315	,55328	,55340	,55352	,55364	,55376
358	,55388	,55400	,55413	,55425	,55437	,55449	,55461	,55473	,55485	,55497
359	,55509	,55521	,55534	,55546	,55558	,55570	,55582	,55594	,55606	,55618
360	,55630	,55642	,55654	,55666	,55678	,55690	,55703	,55715	,55727	,55739
361	,55751	,55763	,55775	,55787	,55799	,55811	,55823	,55835	,55847	,55859
362	,55871	,55883	,55895	,55907	,55919	,55931	,55943	,55955	,55967	,55979
363	,55991	,56003	,56015	,56026	,56038	,56050	,56062	,56074	,56086	,56098
364	,56110	,56122	,56134	,56146	,56158	,56170	,56182	,56194	,56205	,56217
365	,56229	,56241	,56253	,56265	,56277	,56289	,56301	,56312	,56324	,56336
366	,56348	,56360	,56372	,56384	,56395	,56407	,56419	,56431	,56443	,56455
367	,56467	,56478	,56490	,56502	,56514	,56526	,56537	,56549	,56561	,56573
368	,56585	,56597	,56608	,56620	,56632	,56644	,56655	,56667	,56679	,56691
369	,56703	,56714	,56726	,56738	,56750	,56761	,56773	,56785	,56797	,56808
370	,56820	,56832	,56844	,56855	,56867	,56879	,56890	,56902	,56914	,56926
371	,56937	,56949	,56961	,56972	,56984	,56996	,57008	,57019	,57031	,57043
372	,57054	,57066	,57078	,57089	,57101	,57113	,57124	,57136	,57148	,57159
373	,57171	,57182	,57194	,57206	,57217	,57229	,57241	,57252	,57264	,57275
374	,57287	,57299	,57310	,57322	,57334	,57345	,57357	,57368	,57380	,57392
375	,57403	,57415	,57426	,57438	,57449	,57461	,57473	,57484	,57496	,57507
376	,57519	,57530	,57542	,57553	,57565	,57576	,57588	,57600	,57611	,57623
377	,57634	,57646	,57657	,57669	,57680	,57692	,57703	,57715	,57726	,57738
378	,57749	,57761	,57772	,57784	,57795	,57807	,57818	,57829	,57841	,57852
379	,57864	,57875	,57887	,57898	,57910	,57921	,57933	,57944	,57955	,57967
380	,57978	,57990	,58001	,58013	,58024	,58035	,58047	,58058	,58070	,58081
381	,58092	,58104	,58115	,58127	,58138	,58149	,58161	,58172	,58184	,58195
382	,58206	,58218	,58229	,58240	,58252	,58263	,58274	,58286	,58297	,58308
383	,58320	,58331	,58342	,58354	,58365	,58376	,58388	,58399	,58410	,58422
384	,58433	,58444	,58456	,58467	,58478	,58490	,58501	,58512	,58523	,58535
385	,58546	,58557	,58569	,58580	,58591	,58602	,58614	,58625	,58636	,58647
386	,58659	,58670	,58681	,58692	,58704	,58715	,58726	,58737	,58749	,58760
387	,58771	,58782	,58793	,58805	,58816	,58827	,58838	,58850	,58861	,58872
388	,58883	,58894	,58905	,58917	,58928	,58939	,58950	,58961	,58973	,58984
389	,58995	,59006	,59017	,59028	,59040	,59051	,59062	,59073	,59084	,59095
390	,59106	,59118	,59129	,59140	,59151	,59162	,59173	,59184	,59195	,59207
391	,59218	,59229	,59240	,59251	,59262	,59273	,59284	,59295	,59306	,59317
392	,59329	,59340	,59351	,59362	,59373	,59384	,59395	,59406	,59417	,59428
393	,59439	,59450	,59461	,59472	,59483	,59494	,59505	,59516	,59527	,59539
394	,59550	,59561	,59572	,59583	,59594	,59605	,59616	,59627	,59638	,59649
395	,59660	,59671	,59682	,59693	,59704	,59714	,59726	,59737	,59748	,59758
396	,59769	,59780	,59791	,59802	,59813	,59824	,59835	,59846	,59857	,59868
397	,59879	,59890	,59901	,59912	,59923	,59934	,59945	,59956	,59967	,59977
398	,59988	,59999	,60010	,60021	,60032	,60043	,60053	,60065	,60075	,60086
399	,60097	,60108	,60119	,60130	,60141	,60152	,60162	,60173	,60184	,60195
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 4000 to 4600. Logs. from ,60206 to ,66276.

N°	0	1	2	3	4	5	6	7	8	9
400	,60206	,60217	,60228	,60239	,60249	,60260	,60271	,60282	,60293	,60304
401	,60314	,60325	,60336	,60347	,60358	,60368	,60379	,60390	,60401	,60412
402	,60423	,60433	,60444	,60455	,60466	,60477	,60487	,60498	,60509	,60520
403	,60530	,60541	,60552	,60563	,60574	,60584	,60595	,60606	,60617	,60627
404	,60638	,60649	,60660	,60670	,60681	,60692	,60703	,60713	,60724	,60735
405	,60745	,60756	,60767	,60778	,60788	,60799	,60810	,60820	,60831	,60842
406	,60853	,60863	,60874	,60885	,60895	,60906	,60917	,60927	,60938	,60949
407	,60959	,60970	,60981	,60991	,61002	,61013	,61023	,61034	,61045	,61055
408	,61066	,61077	,61087	,61098	,61109	,61119	,61130	,61140	,61151	,61162
409	,61172	,61183	,61194	,61204	,61215	,61225	,61236	,61247	,61257	,61268
410	,61278	,61289	,61300	,61310	,61321	,61331	,61342	,61352	,61363	,61374
411	,61384	,61395	,61405	,61416	,61426	,61437	,61447	,61458	,61469	,61479
412	,61490	,61500	,61511	,61521	,61532	,61542	,61553	,61563	,61574	,61584
413	,61590	,61605	,61616	,61626	,61637	,61647	,61658	,61668	,61679	,61689
414	,61700	,61710	,61721	,61731	,61742	,61752	,61763	,61773	,61784	,61794
415	,61805	,61815	,61826	,61836	,61847	,61857	,61867	,61878	,61888	,61899
416	,61909	,61920	,61930	,61941	,61951	,61961	,61972	,61982	,61993	,62003
417	,62014	,62024	,62034	,62045	,62055	,62066	,62076	,62086	,62097	,62107
418	,62118	,62128	,62138	,62149	,62159	,62169	,62180	,62190	,62201	,62211
419	,62221	,62232	,62242	,62252	,62263	,62273	,62283	,62294	,62304	,62315
420	,62325	,62335	,62346	,62356	,62366	,62377	,62387	,62397	,62408	,62418
421	,62428	,62438	,62449	,62459	,62469	,62480	,62490	,62500	,62511	,62521
422	,62531	,62541	,62552	,62562	,62572	,62583	,62593	,62603	,62613	,62624
423	,62634	,62644	,62655	,62665	,62675	,62685	,62696	,62706	,62716	,62726
424	,62737	,62747	,62757	,62767	,62777	,62788	,62798	,62808	,62818	,62829
425	,62839	,62849	,62859	,62869	,62880	,62890	,62900	,62910	,62921	,62931
426	,62941	,62951	,62961	,62971	,62982	,62992	,63002	,63012	,63022	,63033
427	,63043	,63053	,63063	,63073	,63083	,63094	,63104	,63114	,63124	,63134
428	,63144	,63154	,63165	,63175	,63185	,63195	,63205	,63215	,63225	,63236
429	,63246	,63256	,63266	,63276	,63286	,63296	,63306	,63316	,63327	,63337
430	,63347	,63357	,63367	,63377	,63387	,63397	,63407	,63417	,63428	,63438
431	,63448	,63458	,63468	,63478	,63488	,63498	,63508	,63518	,63528	,63538
432	,63548	,63558	,63568	,63578	,63589	,63599	,63609	,63619	,63629	,63639
433	,63649	,63659	,63669	,63679	,63689	,63699	,63709	,63719	,63729	,63739
434	,63749	,63759	,63769	,63779	,63789	,63800	,63809	,63819	,63829	,63839
435	,63849	,63859	,63869	,63879	,63889	,63899	,63909	,63919	,63929	,63939
436	,63949	,63959	,63969	,63978	,63988	,63998	,64008	,64018	,64028	,64038
437	,64048	,64058	,64068	,64078	,64088	,64098	,64108	,64118	,64128	,64137
438	,64147	,64157	,64167	,64177	,64187	,64197	,64207	,64217	,64227	,64237
439	,64246	,64256	,64266	,64276	,64286	,64296	,64306	,64316	,64325	,64335
440	,64345	,64355	,64365	,64375	,64385	,64395	,64404	,64414	,64424	,64434
441	,64444	,64454	,64463	,64473	,64483	,64493	,64503	,64513	,64523	,64532
442	,64542	,64552	,64562	,64572	,64581	,64591	,64601	,64611	,64621	,64631
443	,64640	,64650	,64660	,64670	,64680	,64689	,64699	64709	,64719	,64728
444	,64738	,64748	,64758	,64768	,64777	,64787	,64797	,64807	,64816	,64826
445	,64836	,64846	,64855	,64865	,64875	,64885	,64894	,64904	,64914	,64924
446	,64933	,64943	,64953	,64963	,64972	,64982	,64992	,65002	,65011	,65021
447	,65031	,65040	,65050	,65060	,65070	,65079	,65089	,65099	,65108	,65118
448	,65128	,65137	,65147	,65157	,65167	,65176	,65186	,65196	,65205	,65215
449	,65225	,65234	,65244	,65254	,65263	,65273	,65283	.65292	,65302	,65312
450	,65321	,65331	,65340	,65350	,65360	,65369	,65379	,65389	,65398	,65408
451	,65418	,65427	,65437	,65446	,65456	,65466	,65475	,65485	,65495	,65504
452	,65514	,65523	,65533	,65543	,65552	,65562	,65571	,65581	,65591	,65600
453	,65610	,65619	,65629	,65639	,65648	,65658	,65667	,65677	,65686	,65696
454	,65706	,65715	,65725	,65734	,65744	,65753	,65763	,65772	,65782	,65792
455	,65801	,65811	,65820	,65830	,65839	,65849	,65858	,65868	,65877	,65887
456	,65896	,65906	,65915	,65925	,65935	,65944	,65954	,65963	,65973	,65984
457	,65992	,66001	,66011	,66020	,66030	,66039	,66049	,66058	,66068	,66077
458	,66086	,66096	,66105	,66115	,66124	,66134	,66143	,66153	,66162	,66172
459	,66181	,66191	,66200	,66210	,66219	,66228	,66238	,66247	,66257	,66266
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 4600 to 5200. Logs. from ,66276 to ,71600.

N°	0	1	2	3	4	5	6	7	8	9
460	,66276	,66285	,66295	,66304	,66313	,66323	,66332	,66342	,66351	,66361
461	,66370	,66379	,66389	,66398	,66408	,66417	,66427	,66436	,66445	,66455
462	,66464	,66474	,66483	,66492	,66502	,66511	,66521	,66530	,66539	,66549
463	,66558	,66567	,66577	,66586	,66596	,66605	,66614	,66624	,66633	,66642
464	,66652	,66661	,66670	,66680	,66689	,66699	,66708	,66717	,66727	,66736
465	,66745	,66755	,66764	,66773	,66783	,66792	,66801	,66810	,66820	,66829
466	,66839	,66848	,66857	,66866	,66876	,66885	,66894	,66904	,69913	,66922
467	,66932	,66941	,66950	,66960	,66969	,66978	,66987	,66997	,67006	,67015
468	,67025	,67034	,67043	,67052	,67062	,67071	,67080	,67089	,67099	,67108
469	,67117	,67126	,67136	,67145	,67154	,67164	,67173	,67182	,67191	,67200
470	,67210	,67219	,67228	,67237	,67247	,67256	,67265	,67274	,67284	,67293
471	,67302	,67311	,67320	,67330	,67339	,67348	,67357	,67367	,67376	,67385
472	,67394	,67403	,67413	,67422	,67431	,67440	,67449	,67459	,67468	,67477
473	,67486	,67495	,67504	,67514	,67523	,67532	,67541	,67550	,67559	,67569
474	,67578	,67587	,67596	,67605	,67614	,67624	,67633	,67642	,67651	,67660
475	,67669	,67678	,67688	,67697	,67706	,67715	,67724	,67733	,67742	,67752
476	,67761	,67770	,67779	,67788	,67797	,67806	,67815	,67824	,67834	,67843
477	,67852	,67861	,67870	,67879	,67888	,67897	,67906	,67915	,67925	,67934
478	,67943	,67952	,67961	,67970	,67979	,67988	,67997	,68006	,68015	,68024
479	,68033	,68043	,68052	,68061	,68070	,68079	,68088	,68097	,68106	,68115
480	,68124	,68133	,68142	,68151	,68160	,68169	,68178	,68187	,68196	,68205
481	,68214	,68223	,68233	,68242	,68251	,68260	,68269	,68278	,68287	,68296
482	,68305	,68314	,68323	,68332	,68341	,68350	,68359	,68368	,68377	,68386
483	,68395	,68404	,68413	,68422	,68431	,68440	,68449	,68458	,68467	,68476
484	,68484	,68493	,68502	,68511	,68520	,68529	,68538	,68547	,68556	,68565
485	,68574	,68583	,68592	,68601	,68610	,68619	,68628	,68637	,68646	,68655
486	,68664	,68673	,68681	,68690	,68699	,68708	,68717	,68726	,68735	,68744
487	,68753	,68762	,68771	,68780	,68788	,68797	,68806	,68815	,68824	,68833
488	,68842	,68851	,68860	,68869	,68878	,68886	,68895	,68904	,68913	,68922
489	,68931	,68940	,68048	,68957	,68966	,68975	,68984	,68993	,69002	,69011
490	,69020	,69028	,69037	,69046	,69055	,69064	,69073	,69082	,69090	,69099
491	,69108	,69117	,69126	,69135	,69143	,69152	,69161	,69170	,69179	,69188
492	,69196	,69205	,69214	,69223	,69232	,69241	,69249	,69258	,69267	,69276
493	,69285	,69293	,69302	,69311	,69320	,69329	,69337	,69346	,69355	,69364
494	,69373	,69381	,69390	,69399	,69408	,69417	,69425	,69434	,69443	,69452
495	,69460	,69469	,69478	,69487	,69496	,69504	,69513	,69522	,69531	,69539
496	,69548	,69557	,69566	,69574	,69583	,69592	,69601	,69609	,69618	,69627
497	,69636	,69644	,69653	,69662	,69671	,69679	,69688	,69697	,69705	,69714
498	,69723	,69732	,69740	,69749	,69758	,69766	,69775	,69784	,69793	,69801
499	,69810	,69819	,69827	,69836	,69845	,69853	,69862	,69871	,69880	,69888
500	,69897	,69906	,69914	,69923	,69932	,69940	,69949	,69958	,69966	,69975
501	,69984	,69992	,70001	,70010	,70018	,70027	,70036	,70044	,70053	,70062
502	,70070	,70079	,70088	,70096	,70105	,70114	,70122	,70131	,70139	,70148
503	,70157	,70165	,70174	,70183	,70191	,70200	,70209	,70217	,70226	,70234
504	,70243	,70252	,70260	,70269	,70277	,70286	,70295	,70303	,70312	,70320
505	,70329	,70338	,70346	,70355	,70363	,70372	,70381	,70389	,70398	,70406
506	,70415	,70424	,70432	,70441	,70449	,70458	,70466	,70475	,70484	,70492
507	,70501	,70509	,70518	,70526	,70535	,70544	,70552	,70561	,70569	,70578
508	,70586	,70595	,70603	,70612	,70620	,70629	,70638	,70646	,70655	,70663
509	,70672	,70680	,70689	,70697	,70706	,70714	,70723	,70731	,70740	,70748
510	,70757	,70765	,70774	,70783	,70791	,70800	,70808	,70817	,70825	,70834
511	,70842	,70851	,70859	,70868	,70876	,70885	,70893	,70901	,70910	,70918
512	,70927	,70935	,70944	,70952	,70961	,70969	,70978	,70986	,70995	,71003
513	,71012	,71020	,71029	,71037	,71045	,71054	,71062	,71071	,71079	,71088
514	,71096	,71105	,71113	,71122	,71130	,71138	,71147	,71155	,71164	,71172
515	,71181	,71189	,71198	,71206	,71214	,71223	,71231	,71240	,71248	,71256
516	,71265	,71273	,71282	,71290	,71299	,71307	,71315	,71324	,71332	,71341
517	,71349	,71357	,71366	,71374	,71383	,71391	,71399	,71408	,71416	,71425
518	,71433	,71441	,71450	,71458	,71466	,71475	,71483	,71492	,71500	,71508
519	,71517	,71525	,71533	,71542	,71550	,71559	,71567	,71575	,71584	,71592
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 5200 to 5800. Logs. from ,71600 to ,76343.

N°	0	1	2	3	4	5	6	7	8	9
520	,71600	,71609	,71617	,71625	,71634	,71642	,71650	,71659	,71667	,71675
521	,71684	,71692	,71700	,71709	,71717	,71725	,71734	,71742	,71750	,71759
522	,71767	,71775	,71784	,71792	,71800	,71809	,71817	,71825	,71834	,71842
523	,71850	,71858	,71867	,71875	,71883	,71892	,71900	,71908	,71916	,71925
524	,71933	,71941	,71950	,71958	,71966	,71974	,71983	,71991	,71999	,72008
525	,72016	,72024	,72032	,72041	,72049	,72057	,72065	,72074	,72082	,72090
526	,72099	,72107	,72115	,72123	,72132	,72140	,72148	,72156	,72165	,72173
527	,72181	,72189	,72197	,72206	,72214	,72222	,72230	,72239	,72247	,72255
528	,72263	,72272	,72280	,72288	,72296	,72304	,72313	,72321	,72329	,72337
529	,72346	,72354	,72362	,72370	,72378	,72387	,72395	,72403	,72411	,72419
530	,72428	,72436	,72444	,72452	,72460	,72468	,72477	,72485	,72493	,72501
531	,72509	,72518	,72526	,72534	,72542	,72550	,72558	,72567	,72575	,72583
532	,72591	,72599	,72607	,72616	,72624	,72632	,72640	,72648	,72656	,72665
533	,72673	,72681	,72689	,72697	,72705	,72713	,72722	,72730	,72738	,72746
534	,72754	,72762	,72770	,72778	,72787	,72795	,72803	,72811	,72819	,72827
535	,72835	,72843	,72852	,72860	,72868	,72876	,72884	,72892	,72900	,72908
536	,72916	,72925	,72933	,72941	,72949	,72957	,72965	,72973	,72981	,72989
537	,72997	,73005	,73014	,73022	,73030	,73038	,73046	,73054	,73062	,73070
538	,73078	,73086	,73094	,73102	,73110	,73119	,73127	,73135	,73143	,73151
539	,73159	,73167	,73175	,73183	,73191	,73199	,73207	,73215	,73223	,73231
540	,73239	,73247	,73255	,73263	,73271	,73280	,73288	,73296	,73304	,73311
541	,73320	,73328	,73336	,73344	,73352	,73360	,73368	,73376	,73384	,73392
542	,73400	,73408	,73416	,73424	,73432	,73440	,73448	,73456	,73464	,73472
543	,73480	,73488	,73496	,73504	,73512	,73520	,73528	,73536	,73544	,73552
544	,73560	,73568	,73576	,73584	,73592	,73600	,73608	,73616	,73624	,73632
545	,73640	,73648	,73656	,73663	,73671	,73679	,73687	,73695	,73703	,73711
546	,73719	,73727	,73735	,73743	,73751	,73759	,73767	,73775	,73783	,73791
547	,73799	,73807	,73815	,73822	,73830	,73838	,73846	,73854	,73862	,73870
548	,73878	,73886	,73894	,73902	,73910	,73918	,73926	,73933	,73941	,73949
549	,73957	,73965	,73973	,73981	,73989	,73997	,74005	,74013	,74020	,74028
550	,74036	,74044	,74052	,74060	,74068	,74076	,74084	,74091	,74099	,74107
551	,74115	,74123	,74131	,74139	,74147	,74155	,74162	,74170	,74178	,74186
552	,74194	,74202	,74210	,74217	,74225	,74233	,74241	,74249	,74257	,74265
553	,74272	,74280	,74288	,74296	,74304	,74312	,74320	,74327	,74335	,74343
554	,74351	,74359	,74367	,74374	,74382	,74390	,74398	,74406	,74414	,74421
555	,74429	,74437	,74445	,74453	,74461	,74468	,74476	,74484	,74492	,74500
556	,74507	,74515	,74523	,74531	,74539	,74546	,74554	,74562	,74570	,74578
557	,74585	,74593	,74601	,74609	,74617	,74624	,74632	,74640	,74648	,74656
558	,74663	,74671	,74679	,74687	,74694	,74702	,74710	,74718	,74726	,74733
559	,74741	,74749	,74757	,74764	,74772	,74780	,74788	,74795	,74803	,74811
560	,74819	,74827	,74834	,74842	,74850	,74858	,74805	,74873	,74881	,74888
561	,74896	,74904	,74912	,74919	,74927	,74935	,74943	,74950	,74958	,74966
562	,74974	,74981	,74989	,74997	,75004	,75012	,75020	,75028	,75035	,75043
563	,75051	,75059	,75066	,75074	,75082	,75089	,75097	,75105	,75112	,75120
564	,75128	,75136	,75143	,75151	,75159	,75166	,75174	,75182	,75189	,75197
565	,75205	,75212	,75220	,75228	,75236	,75243	,75251	,75259	,75266	,75274
566	,75282	,75289	,75297	,75305	,75312	,75320	,75328	,75335	,75343	,75351
567	,75358	,75366	,75374	,75381	,75389	,75397	,75404	,75412	,75419	,75427
568	,75435	,75442	,75450	,75458	,75465	,75473	,75481	,75488	,75496	,75503
569	,75511	,75519	,75526	,75534	,75542	,75549	,75557	,75565	,75572	,75580
570	,75587	,75595	,75603	,75610	,75618	,75626	,75633	,75641	,75648	,75656
571	,75664	,75671	,75679	,75686	,75694	,75702	,75709	,75717	,75724	,75732
572	,75740	,75747	,75755	,75762	,75771	,75777	,75785	,75793	,75800	,75808
573	,75815	,75823	,75831	,75838	,75846	,75854	,75861	,75868	,75876	,75884
574	,75891	,75899	,75906	,75914	,75921	,75929	,75937	,75944	,75952	,75959
575	,75967	,75974	,75982	,75989	,75997	,76004	,76012	,76020	,76027	,76035
576	,76042	,76050	,76057	,76065	,76072	,76080	,76087	,76095	,76102	,76110
577	,76118	,76125	,76133	,76140	,76148	,76155	,76162	,76170	,76178	,76185
578	,76193	,76200	,76208	,76215	,76223	,76230	,76238	,76245	,76253	,76260
579	,76268	,76275	,76283	,76290	,76298	,76305	,76313	,76320	,76328	,76335
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 5800 to 6400. Logs. from ,76343 to ,80618.

N°	0	1	2	3	4	5	6	7	8	9
580	,76343	,76350	,76358	,76365	,76373	,76380	,76388	,76395	,76403	,76410
581	,76418	,76425	,76433	,76440	,76447	,76455	,76462	,76470	,76477	,76485
582	,76492	,76500	,76507	,76515	,76522	,76530	,76537	,76544	,76552	,76559
583	,76567	,76574	,76582	,76589	,76597	,76604	,76611	,76619	,76626	,76634
584	,76641	,76649	,76656	,76664	,76671	,76678	,76686	,76693	,76701	,76708
585	,76716	,76723	,76730	,76738	,76745	,76753	,76760	,76767	,76775	,76782
586	,76790	,76797	,76804	,76812	,76819	,76827	,76834	,76842	,76849	, 6856
587	,76864	,76871	,76879	,76886	,76893	,76901	,76908	,76916	,76923	,76930
588	,76938	,76945	,76952	,76960	,76967	,76975	,76982	,76989	,76997	,77004
589	,77011	,77019	,77026	,77034	,77041	,77048	,77056	,77063	,77070	,77078
590	,77085	,77093	,77100	,77107	,77115	,77122	,77129	,77137	,77144	,77151
591	,77159	,77166	,77173	,77181	,77188	,77195	,77203	,77210	,77217	,77225
592	,77232	,77239	,77247	,77254	,77261	,77269	,77276	,77283	,77291	,77298
593	,77305	,77313	,77320	,77327	,77335	,77342	,77349	,77357	,77364	,77371
594	,77379	,77386	,77393	,77401	,77408	,77415	,77422	,77430	,77437	,77444
595	,77452	,77459	,77466	,77474	,77481	,77488	,77495	,77503	,77510	,77517
596	,77525	,77532	,77539	,77546	,77554	,77561	,77568	,77576	,77583	,77590
597	,77597	,77605	,77612	,77619	,77626	,77634	,77641	,77648	,77656	,77663
598	,77670	,77677	,77685	,77692	,77699	,77706	,77714	,77721	,77728	,77735
599	,77743	,77750	,77757	,77764	,77772	,77779	,77786	,77793	,77801	,77808
600	,77815	,77822	,77810	,77837	,77844	,77851	,77858	,77866	,77873	,77880
601	,77887	,77895	,77902	,77909	,77916	,77924	,77931	,77938	,77945	,77952
602	,77960	,77967	,77974	,77981	,77988	,77996	,78003	,78010	,78017	,78024
603	,78032	,78039	,78046	,78053	,78060	,78068	,78075	,78082	,78089	,78096
604	,78104	,78111	,78118	,78125	,78132	,78140	,78147	,78154	,78161	,78168
605	,78175	,78183	,78190	,78197	,78204	,78211	,78219	,78226	,78233	,78240
606	,78247	,78254	,78262	,78269	,78276	,78283	,78290	,78297	,78305	,78312
607	,78319	,78326	,78333	,78340	,78347	,78355	,78362	,78369	,78376	,78383
608	,78390	,78397	,78405	,78412	,78419	,78426	,78433	,78440	,78447	,78455
609	,78462	,78469	,78476	,78483	,78490	,78497	,78504	,78512	,78519	,78526
610	,78533	,78540	,78547	,78554	,78561	,78569	,78576	,78583	,78590	,78597
611	,78604	,78611	,78618	,78625	,78632	,78640	,78647	,78654	,78661	,78668
612	,78675	,78682	,78689	,78696	,78703	,78711	,78718	,78725	,78732	,78739
613	,78746	,78753	,78760	,78767	,78774	,78781	,78788	,78796	,78803	,78810
614	,78817	,78824	,78831	,78838	,78845	,78852	,78859	,78866	,78873	,78880
615	,78887	,78895	,78902	,78909	,78915	,78923	,78630	,78937	,78944	,78951
616	,78958	,78965	,78972	,78979	,78986	,78993	,79000	,79007	,79014	,79021
617	,79028	,79036	,79043	,79050	,79057	,79064	,79071	,79078	,79085	,79002
618	,79099	,79106	,79113	,79120	,79127	,79134	,79141	,79148	,79155	,79162
619	,79169	,79176	,79183	,79190	,79197	,79204	,79211	,79218	,79225	,79232
620	,79239	,79246	,79[illegible]53	,79260	,79267	,79274	,79281	,79288	,79295	,79302
621	,79309	,79316	,79323	,79330	,79337	,79344	,79351	,79358	,79365	,79372
622	,79379	,79386	,79393	,79400	,79407	,79414	,79421	,79428	,79435	,79442
623	,79449	,79456	,79463	,79470	,79477	,79484	,79491	,79498	,79504	,79511
624	,79518	,79525	,79532	,79539	,79546	,79553	,79560	,79567	,79574	,79581
625	,79588	,79595	,79602	,79609	,79616	,79623	,79630	,79637	,79644	,70650
626	,79657	,79664	,79671	,79678	,79685	,79692	,79699	,79706	,79713	,79720
627	,79727	,79734	,79741	,79747	,79754	,79761	,79768	,79775	,79782	,79789
628	,79796	,79803	,79810	,79817	,79824	,79830	,79837	,79844	,79851	,79858
629	,79865	,79872	,79879	,79886	,79893	,79900	,79906	,79913	,79920	,79927
630	,79934	,79941	,79948	,79955	,79962	,79968	,79975	,79982	,79989	,79996
631	,80003	,80010	,80017	,80024	,80030	,80037	,80044	,80051	,80058	,80065
632	,80072	,80079	,80085	,80092	,80099	,80106	,80113	,80120	,80127	,80133
633	,80140	,80147	,80154	,80161	,80168	,80175	,80181	,80188	,80195	,80202
634	,80209	,80216	,80223	,80229	,80237	,80243	,80250	,80257	,80264	,80270
635	,80277	,80284	,80291	,80298	,80305	,80312	,80318	,80325	,80332	,80339
636	,80346	,80352	,80359	,80366	,80373	,80380	,80387	,80393	,80400	,80407
637	,80414	,80421	,80428	,80434	,80441	,80448	,80455	,80462	,80468	,80475
638	,80482	,80489	,80496	,80502	,80509	,80516	,80523	,80530	,80536	,80543
639	,80550	,80557	,80564	,80570	,80577	,80584	,80591	,80598	,80605	,80611
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 6400 to 7000. Logs. from ,80618 to ,84510.

N°	0	1	2	3	4	5	6	7	8	9
640	,80618	,80625	,80632	,80638	,80645	,80652	,80659	,80665	,80672	,80679
641	,80686	,80693	,80699	,80706	,80713	,80720	,80726	,80733	,80740	,80747
642	,80753	,80760	,80767	,80774	,80781	,80787	,80794	,80801	,80807	,80814
643	,80821	,80828	,80835	,80841	,80848	,80855	,80862	,80868	,80875	,80882
644	,80889	,80895	,80902	,80909	,80915	,80922	,80929	,80936	,80942	,80949
645	,80956	,80963	,80969	,80976	,80983	,80990	,80996	,81003	,81010	,81016
645	,81023	,81030	,81037	,81043	,81050	,81057	,81064	,81070	,81077	,81084
647	,81090	,81097	,81104	,81111	,81117	,81124	,81131	,81137	,81144	,81151
648	,81157	,81164	,81171	,81178	,81184	,81191	,81198	,81204	,81211	,81218
649	,81224	,81231	,81238	,81244	,81251	,81258	,81265	,81271	,81278	,81285
650	,81291	,81298	,81305	,81311	,81318	,81325	,81331	,81338	,81345	,81351
651	,81358	,81365	,81371	,81378	,81385	,81391	,81398	,81405	,81411	,81418
652	,81425	,81431	,81438	,81445	,81451	,81458	,81465	,81471	,81478	,81485
653	,81491	,81498	,81505	,81511	,81518	,81525	,81531	,81538	,81544	,81551
654	,81558	,81564	,81571	,81578	,81584	,81591	,81598	,81604	,81611	,81617
655	,81624	,81631	,81637	,81644	,81651	,81657	,81664	,81670	,81677	,81684
656	,81690	,81697	,81704	,81710	,81717	81723	,81730	,81737	,81743	,81750
657	,81756	,81763	,81770	,81776	,81783	,81790	,81796	,81803	,81809	,81816
658	,81823	,81829	,81836	,81842	,81849	,81856	,81862	,81869	,81875	,81882
659	,81888	,81895	,81902	,81908	,81915	,81921	,81928	,81935	,81941	,81948
660	,81954	,81961	,81967	,81974	,81981	,81987	,81994	,82000	,82007	,82014
661	,82020	,82027	,82033	,82040	,82046	,82053	,82059	,82066	,82073	,82079
662	,82086	,82092	,82099	,82105	,82112	,82119	,82125	,82132	,82138	,82145
663	,82151	,82158	,82164	,82171	,82177	,82184	,82191	,82197	,82204	,82210
664	,82217	,82223	,82230	,82236	,82243	,82249	,82256	,82263	,82269	,82276
665	,82282	,82289	,82295	,82302	,82308	,82315	,82321	,82328	,82334	,82341
666	,82347	,82354	,82360	,82367	,82373	,82380	,82386	,82393	,82400	,82406
667	,82413	,82419	,82426	,82432	,82439	,82445	,82452	,82458	,82464	,82471
668	,82478	,82484	,82491	,82497	,82504	,82510	,82517	,82523	,82529	,82536
669	,82543	,82549	,82556	,82562	,82569	,82575	,82581	,82588	,82594	,82601
670	,82607	,82614	,82620	,82627	,82633	,82640	,82646	,82653	,82659	,82666
671	,82672	,82679	,82685	,82692	,82698	,82704	,82711	,82717	,82724	,82730
672	,82737	,82743	,82750	,82756	,82763	,82769	,82776	,82782	,82789	,82795
673	,82801	,82808	,82814	,82821	,82827	,82834	,82840	,82847	,82853	,82859
674	,82866	,82872	,82879	,82885	,82892	,82898	,82905	,82911	,82917	,82924
675	,82930	,82937	,82943	,82950	,82956	,82962	,82969	,82975	,82982	,82988
676	,82995	,83001	,83007	,83014	,83020	,83027	,83033	,83040	,83046	,83052
677	,83059	,83065	,83072	,83078	,83084	,83091	,83097	,83104	,83110	,83117
678	,83123	,83129	,83136	,83142	,83149	,83155	,83161	,83168	,83174	,83181
679	,83187	,83193	,83200	,83206	,83212	,83219	,83225	,83232	,83238	,83244
680	,83251	,83257	,83264	,83270	,83276	,83283	,83289	,83296	,83302	,83308
681	,83315	,83321	,83327	,83334	,83340	,83347	,83353	,83359	,83366	,83372
682	,83378	,83385	,83391	,83397	,83404	,83410	,83417	,83423	,83429	,83436
683	,83442	,83448	,83455	,83461	,83467	,83474	,83480	,83487	,83493	,83499
684	,83506	,83512	,83518	,83525	,83531	,83537	,83544	,83550	,83556	,83563
685	,83569	,82575	,83582	,83588	,83594	,83601	,83607	,83613	,83620	,83626
686	,83632	,83639	,83645	,83651	,83658	,83664	,83670	,83677	,83683	,83689
687	,83696	,83702	,83708	,83715	,83721	,83727	,83734	,83740	,83746	,83752
688	,83759	,83765	,83771	,83778	,83784	,83790	,83797	,83803	,83809	,83816
689	,83822	,83828	,83834	,83841	,83847	,83853	,83860	,83866	,83872	,83879
690	,83885	,83891	,83897	,83904	,83910	,83916	,83923	,83929	,83935	,83941
691	,83948	,83954	,83960	,83967	,83973	,83979	,83985	,83992	,83998	,84004
692	,84011	,84017	,84023	,84029	,84036	,84042	,84048	,84054	,84061	,84067
693	,84073	,84080	,84086	,84092	,84098	,84105	,84111	,84117	,84123	,84130
694	,84136	,84142	,84148	,84155	,84161	,84167	,84173	,84180	,84186	,84192
695	,84198	,84205	,84211	,84217	,84223	,84230	,84236	,84242	,84248	,84254
696	,84261	,84267	,84273	,84280	,84286	,84292	,84298	,84305	,84311	,84317
697	,84323	,84329	,84336	,84342	,84348	,84354	,84361	,84367	,84373	,84379
698	,84385	,84392	,84398	,84404	,84410	,84417	,84423	,84429	,84435	,84441
699	,84448	,84454	,84460	,84466	,84473	,84479	,84485	,84491	,84497	,84504
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 7000 to 7600. Logs. from ,84510 to ,88081.

Nº	0	1	2	3	4	5	6	7	8	9
700	,84510	,84516	,84522	,84528	,84535	,84541	,84547	,84553	,84559	,84566
701	,84572	,84578	,84584	,84590	,84596	,84602	,84609	,84615	,84621	,84627
702	,84634	,84640	,84646	,84652	,84658	,84665	,84671	,84677	,84683	,84689
703	,84695	,84701	,84708	,84714	,84720	,84726	,84733	,84739	,84745	,84751
704	,84757	,84763	,84770	,84776	,84782	,84788	,84794	,84800	,84807	,84813
705	,84819	,84825	,84831	,84837	,84843	,84850	,84856	,84862	,84868	,84874
706	,84880	,84887	,84893	,84899	,84905	,84911	,84917	,84923	,84930	,84936
707	,84942	,84948	,84954	,84960	,84960	,84973	,84979	,84985	,84991	,84997
708	,85003	,85009	,85016	,85022	,85028	,85034	,85040	,85046	,85052	,85058
709	,85065	,85071	,85077	,85083	,85089	,85095	,85101	,85107	,85114	,85120
710	,85126	,85132	,85138	,85144	,85150	,85156	,85162	,85169	,85175	,85181
711	,85187	,85193	,85199	,85205	,85211	,85217	,85224	,85230	,85236	,85242
712	,85248	,85254	,85260	,85266	,85272	,85278	,85285	,85291	,85297	,85303
713	,85309	,85315	,85321	,85327	,85333	,85339	,85345	,85352	,85358	,85364
714	,85370	,85376	,85382	,85388	,85394	,85400	,85406	,85412	,85418	,85424
715	,85431	,85437	,85443	,85449	,85455	,85461	,85467	,85473	,85479	,85485
716	,85491	,85497	,85503	,85509	,85516	,85522	,85528	,85534	,85540	,85546
717	,85552	,85558	,85564	,85570	,85576	,85582	,85588	,85594	,85600	,85606
718	,85612	,85618	,85624	,85631	,85637	,85643	,85649	,85655	,85661	,85667
719	,85673	,85679	,85685	,85691	,85697	,85703	,85709	,85715	,85721	,85727
720	,85733	,85739	,85745	,85751	,85757	,85763	,85769	,85775	,85781	,85787
721	,85793	,85799	,85806	,85812	,85818	,85824	,85830	,85836	,85842	,85848
722	,85854	,85860	,85866	,85872	,85878	,85884	,85890	,85896	,85902	,85908
723	,85914	,85920	,85926	,85932	,85938	,85944	,85950	,85956	,85962	,85968
724	,85974	,85980	,85986	,85992	,85998	,86004	,86010	,86016	,86022	,86028
725	,86034	,86040	,86046	,86052	,86058	,86064	,86070	,86076	,86082	,86088
726	,86094	,86100	,86106	,86112	,86118	,86124	,86130	,86135	,86141	,86147
727	,86153	,86159	,86165	,86171	,86177	,86183	,86189	,86195	,86201	,86207
728	,86213	,86219	,86225	,86231	,86237	,86243	,86249	,86255	,86261	,86267
729	,86273	,86279	,86285	,86291	,86297	,86302	,86308	,86314	,86320	,86326
730	,86332	,86338	,86344	,86350	,86357	,86362	,86368	,86374	,86380	,86386
731	,86392	,86398	,86404	,86410	,86415	,86421	,86427	,86433	,86439	,86445
732	,86451	,86457	,86463	,86469	,86475	,86481	,86487	,86493	,86498	,86504
733	,86510	,86516	,86522	,86528	,86534	,86540	,86546	,86552	,86558	,86564
734	,86570	,86575	,86581	,86587	,86593	,86599	,86605	,86611	,86617	,86623
735	,86629	,86635	,86640	,86646	,86652	,86658	,86664	,86670	,86676	,86682
736	,86688	,86694	,86700	,86705	,86711	,86717	,86723	,86729	,86735	,86741
737	,86747	,86753	,86758	,86764	,86770	,86776	,86782	,86788	,86794	,86800
738	,86806	,86811	,86817	,86823	,86829	,86835	,86841	,86847	,86853	,86859
739	,86864	,86870	,86876	,86882	,86888	,86894	,86900	,86906	,86911	,86917
740	,86923	,86929	,86935	,86941	,86947	,86952	,86958	,86964	,86970	,86976
741	,86982	,86988	,86993	,86999	,87005	,87011	,87017	,87023	,87029	,87034
742	,87040	,87046	,87052	,87058	,87064	,87070	,87075	,87081	,87087	,87093
743	,87099	,87105	,87111	,87116	,87122	,87128	,87134	,87140	,87146	,87151
744	,87157	,87163	,87169	,87175	,87181	,87186	,87192	,87198	,87204	,87210
745	,87216	,87221	,87227	,87233	,87239	,87245	,87251	,87256	,87262	,87268
746	,87274	,87280	,87285	,87291	,87297	,87303	,87309	,87315	,87320	,87326
747	,87332	,87338	,87344	,87349	,87355	,87361	,87367	,87373	,87378	,87384
748	,87390	,87396	,87402	,87408	,87413	,87419	,87425	,87431	,87437	,87442
749	,87448	,87454	,87460	,87466	,87471	,87477	,87483	,87489	,87494	,87500
750	,87506	,87512	,87518	,87523	,87529	,87535	,87541	,87547	,87552	,87558
751	,87564	,87570	,87576	,87581	,87587	,87593	,87599	,87604	,87610	,87616
752	,87622	,87628	,87633	,87639	,87645	,87651	,87656	,87662	,87668	,87674
753	,87679	,87685	,87691	,87697	,87702	,87708	,87714	,87720	,87726	,87731
754	,87737	,87743	,87749	,87754	,87760	,87766	,87772	,87777	,87783	,87789
755	,87794	,87800	,87806	,87812	,87818	,87823	,87829	,87835	,87841	,87846
756	,87852	,87858	,87864	,87869	,87875	,87881	,87887	,87892	,87898	,87904
757	,87910	,87915	,87921	,87927	,87932	,87938	,87944	,87950	,87955	,87961
758	,87967	,87973	,87978	,87984	,87990	,87996	,88001	,88007	,88013	,88018
759	,88024	,88030	,88036	,88041	,88047	,88052	,88058	,88064	,88070	,88076
Nº	0	1	2	3	4	5	6	7	8	9

Numbers from 7600 to 8200. Logs. from ,88081 to ,91381.

Nº	0	1	2	3	4	5	6	7	8	9
760	,88081	,88087	,88093	,88098	,88104	,88110	,88116	,88121	,88127	,88133
761	,88138	,88144	,88150	,88156	,88161	,88167	,88173	,88178	,88184	,88190
762	,88195	,88201	,88207	,88213	,88218	,88224	,88230	,88235	,88241	,88247
763	,88252	,88258	,88264	,88269	,88275	,88281	,88287	,88292	,88298	,88304
764	,88309	,88315	,88321	,88326	,88332	,88338	,88343	,88349	,88355	,88360
765	,88366	,88372	,88377	,88383	,88389	,88394	,88400	,88406	,88411	,88417
766	,88423	,88428	,88434	,88440	,88445	,88451	,88457	,88462	,88468	,88474
767	,88479	,88485	,88491	,88496	,88502	,88508	,88513	,88519	,88525	,88530
768	,88536	,88542	,88547	,88553	,88559	,88564	,88570	,88576	,88581	,88587
769	,88593	,88598	,88604	,88610	,88615	,88621	,88626	,88632	,88638	,88643
770	,88649	,88655	,88660	,88666	,88672	,88677	,88683	,88688	,88694	,88700
771	,88705	,88711	,88717	,88722	,88728	,88734	,88739	,88745	,88750	,88756
772	,88762	,88767	,88773	,88779	,88784	,88790	,88795	,88801	,88807	,88812
773	,88818	,88824	,88829	,88835	,88840	,88846	,88852	,88857	,88863	,88868
774	,88874	,88880	,88885	,88891	,88896	,88902	,88908	,88913	,88919	,88925
775	,88930	,88936	,88941	,88947	,88954	,88958	,88964	,88969	,88975	,88981
776	,88986	,88992	,88997	,89003	,89009	,89014	,89020	,89025	,89031	,89036
777	,89042	,89048	,89053	,89059	,89064	,89070	,89075	,89081	,89087	,89092
778	,89098	,89103	,89109	,89115	,89120	,89126	,89131	,89137	,89143	,89148
779	,89154	,89159	,89165	,89170	,89176	,89182	,89187	,89193	,89198	,89204
780	,89209	,89215	,89221	,89226	,89232	,89237	,89243	,89248	,89254	,89259
781	,89265	,89271	,89276	,89282	,89287	,89293	,89298	,89304	,89310	,89315
782	,89321	,89326	,89332	,89337	,89343	,89348	,89354	,89359	,89365	,89371
783	,89376	,89382	,89387	,89393	,89398	,89404	,89409	,89415	,89420	,89426
784	,89432	,89437	,89443	,89448	,89454	,89559	,89465	,89470	,89476	,89481
785	,89487	,89492	,89498	,89504	,89509	,89515	,89520	,89526	,89531	,89537
786	,89542	,89548	,89553	,89559	,89564	,89570	,89575	,89581	,89586	,89 92
787	,89597	,89603	,89608	,89614	,89619	,89625	,89631	,89636	,89642	,89647
788	,89653	,89658	,89664	,89669	,89675	,89680	,89686	,89691	,89697	,89702
789	,89708	,89713	,89719	,89724	,89730	,89735	,89741	,89746	,89752	,89757
790	,89762	,89768	,89774	,89779	,89785	,89790	,89796	,89801	,89807	,89812
791	,89818	,89823	,89829	,89834	,89840	,89845	,89851	,89856	,89861	,89867
792	,89872	,89878	,89883	,89889	,89894	,89900	,89905	,89911	,89916	,89922
793	,89927	,89933	,89938	,89944	,89949	,89955	,89960	,89966	,89971	,89977
794	,89982	,89987	,89993	,89998	,90004	,90009	,90015	,90020	,90026	,90031
795	,90037	,90042	,90048	,90053	,90059	,90064	,90069	,90075	,90080	,90085
796	,90091	,90097	,90102	,90108	,90113	,90119	,90124	,90129	,90135	,90141
797	,90146	,90151	,90157	,90162	,90168	,90173	,90178	,90184	,90189	,90195
798	,90200	,90206	,90211	,90217	,90222	,90227	,90233	,90238	,90244	,90249
799	,90255	,90260	,90265	,90271	,90276	,90282	,90287	,90293	,90298	,90304
800	,90309	,90314	,90320	,90325	,90331	,90336	,90342	,90347	,90352	,90358
801	,90363	,90369	,90374	,90379	,90385	,90390	,90396	,90401	,90407	,90412
802	,90417	,90423	,90428	,90434	,90439	,90444	,90450	,90455	,90461	,90466
803	,90471	,90477	,90482	,90488	,90493	,90499	,90504	,90509	,90515	,90520
804	,90526	,90531	,90536	,90542	,90547	,90553	,90558	,90563	,90569	,90574
805	,90580	,90585	,90590	,90596	,90601	,90606	,90612	,90617	,90622	,90628
806	,90633	,90639	,90644	,90650	,90655	,90660	,90666	,90671	,90677	,90682
807	,90687	,90693	,90698	,90703	,90709	,90714	,90720	,90725	,90730	,90736
808	,90741	,90746	,90752	,90757	,90763	,90768	,90773	,90779	,90784	,90789
809	,90795	,90800	,90806	,90811	,90816	,90822	,90827	,90832	,90838	,90843
810	,90848	,90854	,90859	,90865	,90870	,90875	,90881	,90886	,90891	,90897
811	,90902	,90907	,90913	,90918	,90923	,90929	,90934	,90939	,90945	,90950
812	,90956	,90961	,90966	,90972	,90977	,90982	,90988	,90993	,90998	,91004
813	,91009	,91014	,91020	,91025	,91030	,91036	,91041	,91046	,91052	,91057
814	,91062	,91068	,91073	,91078	,91084	,91089	,91094	,91100	,91105	,91110
815	,91116	,91121	,91126	,91132	,91137	,91142	,91148	,91153	,91158	,91164
816	,91169	,91174	,91180	,91185	,91190	,91196	,91201	,91206	,91212	,91217
817	,91222	,91227	,91233	,91238	,91243	,91249	,91254	,91259	,91265	,91270
818	,91275	,91281	,91286	,91291	,91297	,91301	,91307	,91312	,91318	,91323
819	,91328	,91334	,91339	,91344	,91350	,91355	,91360	,91365	,91371	,91376
Nº	0	1	2	3	4	5	6	7	8	4

Numbers from 8200 to 8800. Logs. from ,91381 to ,94448.

N°	0	1	2	3	4	5	6	7	8	9
820	,91381	,91387	,91392	,91397	,91403	,91408	,91413	,91418	,91424	,91429
821	,91434	,91440	,91445	,91450	,91455	,91461	,91466	,91471	,91477	,91482
822	,91487	,91492	,91498	,91503	,91508	,91514	,91519	,91524	,91529	,91535
823	,91540	,91545	,91550	,91556	,91561	,91566	,91572	,91577	,91582	,91587
824	,91593	,91598	,91603	,91608	,91614	,91619	,91624	,91630	,91635	,91640
825	,91645	,91650	,91656	,91661	,91666	,91672	,91677	,91682	,91687	,91693
826	,91698	,91703	,91708	,91714	,91719	,91724	,91729	,91735	,91740	,91745
827	,91750	,91756	,91761	,91766	,91771	,91777	,91782	,91787	,91792	,91798
828	,91803	,91808	,91813	,91819	,91824	,91829	,91834	,91840	,91845	,91850
829	,91855	,91861	,91866	,91871	,91876	,91882	,91887	,91892	,91897	,91903
830	,91908	,91913	,91918	,91923	,91929	,91934	,91939	,91944	,91950	,91955
831	,91960	,91965	,91970	,91976	,91981	,91986	,91991	,91997	,92002	,92007
832	,92012	,92017	,92023	,92028	,92033	,92038	,92044	,92049	,92054	,92059
833	,92064	,92070	,92075	,92080	,92085	,92091	,92096	,92101	,92106	,92111
834	,92117	,92122	,92127	,92132	,92137	,92143	,92148	,92153	,92158	,92163
835	,92169	,92174	,92179	,92184	,92189	,92195	,92200	,92205	,92210	,92215
836	,92221	,92226	,92231	,92236	,92241	,92247	,92252	,92257	,92262	,92267
837	,92272	,92278	,92283	,92288	,92293	,92298	,92304	,92309	,92314	,92319
838	,92324	,92330	,92335	,92340	,92345	,92350	,92355	,92361	,92366	,92371
839	,92376	,92381	,92386	,92392	,92397	,92402	,92407	,92412	,92418	,92423
840	,92428	,92433	,92438	,92443	,92449	,92454	,92459	,92464	,92469	,92474
841	,92480	,92485	,92490	,92495	,92500	,92505	,92511	,92516	,92521	,92526
842	,92531	,92536	,92541	,92547	,92552	,92557	,92562	,92567	,92572	,92578
843	,92583	,92588	,92593	,92598	,92603	,92608	,92614	,92619	,92624	,92629
844	,92634	,92639	,92644	,92650	,92655	,92660	,92665	,92670	,92675	,92680
845	,92686	,92691	,92696	,92701	,92706	,92711	,92716	,92722	,92727	,92732
846	,92737	,92742	,92747	,92752	,92758	,92763	,92768	,92773	,92778	,92783
847	,92788	,92793	,92799	,92804	,92809	,92814	,92819	,92824	,92829	,92834
848	,92840	,92845	,92850	,92855	,92860	,92865	,92870	,92875	,92880	,92886
849	,92891	,92896	,92901	,92906	,92911	,92916	,92921	,92927	,92932	,92937
850	,92942	,92947	,92952	,92957	,92962	,92967	,92972	,92978	,92983	,92988
851	,92993	,92998	,93003	,93008	,93013	,93018	,93024	,93029	,93034	,93039
852	,93044	,93049	,93054	,93059	,93064	,93069	,93074	,93080	,93085	,93090
853	,93095	,93100	,93105	,93110	,93115	,93120	,93125	,93130	,93136	,93141
854	,93146	,93151	,93156	,93161	,93166	,93171	,93176	,93181	,93186	,93191
855	,93197	,93202	,93207	,93212	,93217	,93222	,93227	,93232	,93237	,93242
856	,93247	,93252	,93257	,93263	,93268	,93273	,93278	,93283	,93288	,93293
857	,93298	,93303	,93308	,93313	,93318	,93323	,93328	,93333	,93339	,93344
858	,93349	,93354	,93359	,93364	,93369	,93374	,93379	,93384	,93389	,93394
859	,93399	,93404	,93409	,93414	,93419	,93425	,93430	,93435	,93440	,93445
860	,93450	,93455	,93460	,93465	,93470	,93475	,93480	,93485	,93490	,93495
861	,93500	,93505	,93510	,93515	,93520	,93525	,93531	,93536	,93541	,93546
862	,93551	,93556	,93561	,93566	,93571	,93576	,93581	,93586	,93591	,93596
863	,93601	,93606	,93611	,93616	,93621	,93626	,93631	,93636	,93641	,93646
864	,93651	,93656	,93661	,93666	,93671	,93676	,93681	,93686	,93692	,93697
865	,93702	,93707	,93712	,93717	,93722	,93727	,93732	,93737	,93742	,93747
866	,93752	,93757	,93762	,93767	,93772	,93777	,93782	,93787	,93792	,93797
867	,93802	,93807	,93812	,93817	,93822	,93827	,93832	,93837	,93842	,93847
868	,93852	,93857	,93862	,93867	,93872	,93877	,93882	,93887	,93892	,93897
869	,93902	,93907	,93912	,93917	,93922	,93927	,93932	,93937	,93942	,93947
870	,93952	,93957	,93962	,93967	,93972	,93977	,93982	,93987	,93992	,93997
871	,94002	,94007	,94012	,94017	,94022	,94027	,94032	,94037	,94047	,94047
872	,94052	,94057	,94062	,94067	,94072	,94076	,94081	,94086	,94091	,94096
873	,94101	,94106	,94111	,94116	,94121	,94126	,94131	,94136	,94141	,94146
874	,94151	,94156	,94161	,94166	,94171	,94176	,94181	,94186	,94191	,94196
875	,94201	,94206	,94211	,94216	,94221	,94226	,94230	,94235	,94240	,94245
876	,94250	,94255	,94260	,94265	,94270	,94275	,94280	,94285	,94290	,94295
877	,943 0	,94305	,94310	,94315	,94320	,94325	,94330	,94335	,94340	,94344
878	,94349	,94354	,94359	,94364	,94369	,94374	,94379	,94384	,94389	,94394
879	,94399	,94404	,94409	,94414	,94419	,94424	,94428	,94433	,94438	,94443
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 8800 to 9400. Logs. from ,94448 to ,97313.

N°	0	1	2	3	4	5	6	7	8	9
880	,94448	,94453	,94458	,94463	,94468	,94473	,94478	,94483	,94488	,94493
881	,94498	,94502	,94507	,94512	,94517	,94522	,94527	,94532	,94537	,94542
882	,94547	,94552	,94557	,94562	,94566	,94571	,94576	,94581	,94586	,94591
883	,94596	,94601	,94609	,94611	,94616	,94621	,94626	,94630	,94635	,94640
884	,94645	,94650	,94655	,94660	,94665	,64670	,94675	,94680	,94684	,94689
885	,94694	,94699	,94704	,94709	,94714	,94719	,94724	,94729	,94734	,94738
886	,94743	,94748	,94753	,94758	,94763	,94768	,94773	,94778	,94783	,94787
887	,94792	,94797	,94802	,94807	,94812	,94817	,94822	,94827	,94831	,94836
888	,94841	,94846	,94851	,94856	,94861	,94866	,94871	,94875	,94880	,94885
889	,94890	,94895	,94900	,94905	,94910	,94915	,94919	,94924	,94929	,94934
890	,94939	,94944	,94949	,94953	,94958	,94963	,94968	,94973	,94978	,94983
891	,94988	,94993	,94997	,95002	,95007	,95012	,95017	,95022	,95027	,95031
892	,95036	,95041	,95046	,95051	,95056	,95061	,65066	,95070	,95075	,95080
893	,95085	,95090	,95095	,95100	,95105	,95109	,95114	,95119	,95124	,95129
894	,95134	,95139	,95143	,95148	,95153	,95158	,95163	,95168	,95173	,95177
895	,95182	,95187	,95192	,95197	,95202	,95207	,95211	,95216	,95221	,95226
896	,95231	,95236	,95240	,95245	,95250	,95255	,95260	,95265	,95270	,95274
897	,95279	,95284	,95289	,95294	,95299	,95303	,95308	,95313	,95318	,95323
898	,95328	,95332	,95337	,95342	,95347	,95352	,95357	,95361	,95366	,95371
899	,95376	,95381	,95386	,95390	,95395	,95400	,95405	,95410	,95425	,95419
900	,95424	,95429	,95434	,95439	,95443	,95448	,95453	,95458	,95463	,95468
901	,95472	,95477	,95482	,95487	,95492	,95497	,95501	,95506	,95511	,95516
902	,95521	,95525	,95530	,95535	,95540	,95545	,95549	,95554	,95559	,95564
903	,95569	,95574	,95578	,95583	,95588	,95593	,95598	,95602	,95607	,95612
904	,95617	,95622	,95626	,95631	,95636	,95641	,95646	,95650	,95655	,95600
905	,95665	,95670	,95674	,95679	,95684	,95689	,95694	,95698	,95703	,95708
906	,95713	,95718	,95722	,95727	,95732	,95737	,95742	,95746	,95751	,95756
907	,95761	,95765	,95771	,95775	,95780	,95785	,95789	,95794	,95799	,95804
908	,95809	,95813	,95818	,95823	,95828	,95832	,95837	,95842	,95847	,95852
909	,95856	,95861	,95866	,95871	,95875	,95880	,95885	,95890	,95895	,95899
910	,95904	,95909	,95914	,95918	,95923	,95928	,95933	,95937	,95942	,95947
911	,95952	,95957	,95961	,95966	,95971	,95976	,95980	,95985	,95990	,95995
912	,95999	,96004	,96009	,96014	,96018	,96023	,96028	,96033	,96038	,96042
913	,96047	,96052	,96057	,96061	,96066	,96071	,96076	,96080	,96085	,96090
914	,96095	,96099	,96104	,96109	,96114	,96118	,96123	,96128	,96133	,96137
915	,96142	,96147	,96152	,96156	,96161	,96165	,96171	,96175	,96180	,96185
916	,96189	,96194	,96199	,96204	,96208	,96213	,96218	,96223	,96227	,96232
917	,96237	,96242	,96246	,96251	,96256	,96261	,96265	,96270	,96275	,96279
918	,96284	,96289	,96293	,96298	,96303	,96308	,96313	,96317	,96322	,96327
919	,96331	,96336	,96341	,96346	,96350	,96355	,96360	,96365	,96369	,96374
920	,96379	,96383	,96388	,96393	,96398	,96402	,96407	,96412	,96416	,96421
921	,96426	,96431	,96435	,96440	,96445	,96449	,96454	,96459	,96464	,96468
922	,96473	,96478	,96482	,96487	,96492	,96497	,96501	,96506	,96511	,96515
923	,96520	,96525	,96530	,96534	,96539	,96544	,96548	,96553	,96558	,96562
924	,96567	,96572	,96577	,96581	,96586	,96591	,96595	,96600	,96605	,96609
925	,96614	,96619	,96624	,96628	,96633	,96638	,96642	,96647	,96651	,96656
926	,96661	,96666	,96670	,96675	,96680	,96684	,96689	,96694	,96699	,96703
927	,96708	,96713	,96717	,96722	,96727	,96731	,96732	,96741	,96745	,96750
928	,96755	,96759	,96764	,96769	,96773	,96778	,96783	,96787	,96792	,96797
929	,96802	,96806	,96811	,96816	,96820	,96825	,96830	,96834	,96839	,96844
930	,96848	,96853	,96858	,96862	,96867	,96872	,96876	,96881	,96886	,96890
931	,96895	,96900	,96904	,96909	,96914	,96918	,96923	,96928	,96932	,96937
932	,96942	,96946	,96951	,96956	,96960	,96965	,96969	,96974	,96979	,96983
933	,96988	,96993	,96997	,97002	,97007	,97011	,97016	,97021	,97025	,97030
934	,97035	,97039	,97044	,97049	,97053	,97058	,97062	,97067	,97072	,97076
935	,97081	,97086	,97090	,97095	,97100	,97104	,97109	,97114	,97118	,97123
936	,97128	,97132	,97137	,97141	,97146	,97151	,97155	,97160	,97165	,97169
937	,97174	,97179	,97183	,97188	,97192	,97197	,97202	,97206	,97211	,97216
938	,97220	,97225	,97229	,97234	,97239	,97243	,97248	,97253	,97257	,97262
939	,97267	,97271	,97276	,97280	,97285	,97290	,97294	,97299	,97303	,97308
N°	0	1	2	3	4	5	6	7	8	9

Numbers from 9400 to 10000. Logs. from ,97313 to ,99996.

N°	0	1	2	3	4	5	6	7	8	9
940	,97313	,97317	,97322	,97326	,97331	,97336	,97340	,97345	,97350	,97354
941	,97359	,97364	,97368	,97373	,97377	,97382	,97387	,97391	,97396	,97400
942	,97405	,97410	,97414	,97419	,97423	,97428	,97433	,97437	,97442	,97447
943	,97451	,97456	,97460	,97465	,97470	,97474	,97479	,97483	,97488	,97492
944	,97597	,97502	,97506	,97511	,97516	,97520	,97525	,97529	,97534	,97539
945	,97543	,97548	,97552	,97557	,97562	,97566	,97571	,97575	,97580	,97584
946	,97589	,97594	,97598	,97603	,97607	,97612	,97617	,97621	,97626	,97630
947	,97635	,97640	,97644	,97649	,97653	,97658	,97662	,97667	,97672	,97676
948	,97681	,97685	,97690	,97694	,97699	,97704	,97708	,97713	,97717	,97722
949	,97727	,97731	,97736	,97740	,97745	,97749	,97754	,97759	,97763	,97768
950	,97772	,97777	,97781	,97786	,97791	,97795	,97800	,97804	,97809	,97813
951	,97818	,97823	,97827	,97832	,97836	,97841	,97845	,97850	,97855	,97859
952	,97864	,97868	,97873	,97877	,97882	,97886	,97891	,97896	,97900	,97905
953	,97909	,97914	,97918	,97923	,97927	,97932	,97937	,97941	,97946	,97950
954	,97955	,97959	,97964	,97968	,97973	,97978	,97982	,97987	,97991	,97996
955	,98000	,98005	,98009	,98014	,98018	,98023	,98028	,98032	,98037	,98041
956	,98046	,98050	,98055	,98059	,98064	,98068	,98073	,98078	,98082	,98087
957	,98091	,98096	,98100	,98105	,98109	,98114	,98118	,98123	,98127	,98132
958	,98136	,98141	,98146	,98150	,98155	,98159	,98164	,98168	,98173	,98177
959	,98182	,98186	,98191	,98195	,98200	,98204	,98209	,98213	,98218	,98223
960	,98227	,98232	,98236	,98241	,98245	,98250	,98254	,98259	,98263	,98268
961	,98272	,98277	,98281	,98286	,98290	,98295	,98299	,98304	,98308	,98313
962	,98317	,98322	,98326	,98331	,98336	,98340	,98345	,98349	,98354	,98358
963	,98363	,98367	,98372	,98376	,98381	,98385	,98399	,98394	,98399	,98403
964	,98408	,98412	,98417	,98421	,98426	,98430	,98435	,98439	,98444	,98448
965	,98453	,98457	,98462	,98466	,98471	,98475	,98480	,98484	,98489	,98493
966	,98498	,98502	,98507	,98511	,98516	,98520	,98525	,98529	,98534	,98538
967	,98543	,98547	,98552	,98556	,98561	,98565	,98570	,98574	,98579	,98583
968	,98587	,98592	,98596	,98601	,98605	,98610	,98614	,98619	,98623	,98628
969	,98632	,98637	,98641	,98646	,98650	,98655	,98659	,98664	,98668	,98673
970	,98677	,98682	,98686	,98691	,98695	,98699	,98704	,98708	,98713	,98717
971	,98722	,98726	,98731	,98735	,98740	,98744	,98749	,98753	,98758	,98762
972	,98767	,98771	,98776	,98780	,98784	,98789	,98793	,98798	,98802	,98807
973	,98811	,98816	,98820	,98825	,98829	,98834	,98838	,98842	,98847	,98851
974	,98856	,98860	,98865	,98869	,98874	,98878	,98883	,98887	,98891	,98896
975	,98900	,98905	,98909	,98914	,98918	,98923	,98927	,98932	,98936	,98940
976	,98945	,98949	,98954	,98958	,98963	,98967	,98972	,98976	,98981	,98985
977	,98989	,98994	,98998	,99003	,99007	,99012	,99016	,99021	,99025	,99029
978	,99034	,99038	,99043	,99047	,99052	,99056	,99060	,99065	,99069	,99074
979	,99078	,99083	,99087	,99092	,99096	,99100	,99105	,99109	,99114	,99118
980	,99123	,99127	,99131	,99136	,99140	,99145	,99149	,99154	,99158	,99162
981	,99167	,99171	,99176	,99180	,99185	,99189	,99193	,99198	,99202	,99207
982	,99211	,99216	,99220	,99224	,99229	,99233	,99238	,99242	,99246	,99251
983	,99255	,99259	,99264	,99269	,99273	,99277	,99282	,99286	,99291	,99295
984	,99299	,99304	,99308	,99313	,99317	,99322	,99326	,99330	,99335	,99339
985	,99344	,99348	,99352	,99357	,99361	,99366	,99370	,99374	,99379	,99383
986	,99388	,99392	,99396	,99401	,99405	,99410	,99414	,99418	,99423	,99427
987	,99437	,99436	,99440	,99445	,99449	,99454	,99458	,99462	,99467	,99471
988	,99476	,99480	,99484	,99489	,99493	,99498	,99502	,99506	,99511	,99515
989	,99520	,99524	,99528	,99533	,99537	,99542	,99546	,99550	,99555	,99559
990	,99563	,99568	,99572	,99577	,99581	,99585	,99590	,99594	,99599	,99603
991	,99607	,99612	,99616	,99620	,99625	,99629	,99634	,99638	,99642	,99647
992	,99651	,99655	,99660	,99664	,99669	,99673	,99677	,99682	,99686	,99690
993	,99695	,99699	,99704	,99708	,99712	,99717	,99721	,99725	,99730	,99734
994	,99739	,99743	,99747	,99752	,99756	,99760	,99765	,99769	,99774	,99778
995	,99782	,99787	,99791	,99795	,99800	,99804	,99808	,99813	,99817	,99822
996	,99826	,99830	,99835	,99839	,99843	,99848	,99852	,99856	,99861	,99865
997	,99869	,99874	,99878	,99883	,99887	,99891	,99896	,99900	,99904	,99909
998	,99913	,99917	,99922	,99926	,99930	,99935	,99939	,99943	,99948	,99952
999	,99956	,99961	,99965	,99971	,99974	,99978	,99983	,99987	,99991	,99996
N°	0	1	2	3	4	5	6	7	8	9

0 Degree

M	Sine	Co-ſine	Tangent	Co-tang.	
0	0,00000	1,00000	0,00000	Infinite	60
1	6,46373	9,99999	6,46373	13,53627	59
2	6,76476	9,99999	6,76476	13,23524	58
3	6,94085	9,99999	6,94085	13,05915	57
4	7,06579	9,99999	7,06579	12,93421	56
5	7,16270	9,99999	7,16270	12,83730	55
6	7,24188	9,99999	7,24188	12,75812	54
7	7,30882	9,99999	7,30882	12,69117	53
8	7,36682	9,99999	7,36682	12,63318	52
9	7,41797	9,99999	7,41797	12,58203	51
10	7,46372	9,99999	7,46373	12,53627	50
11	7,50512	9,99999	7,50512	12,49488	49
12	7,54291	9,99999	7,54291	12,45709	48
13	7,57767	9,99999	7,57767	12,42233	47
14	7,60985	9,99999	7,60986	12,39014	46
15	7,63982	9,99999	7,63982	12,36018	45
16	7,66784	9,99999	7,66785	12,33215	44
17	7,69417	9,99999	7,69418	12,30582	43
18	7,71900	9,99999	7,71900.	12,28100	42
19	7,74248	9,99999	7,74248	12,25752	41
20	7,76475	9,99999	7,76476	12,23524	40
21	7,78 94	9,99999	7,78595	12,21405	39
22	7,80615	9,99999	7,80615	12,19384	38
23	7,82545	9,99999	7,82546	12,17454	37
24	7,84393	9,99999	7,84394	12,15606	36
25	7,86166	9,99999	7,86167	12,13833	35
26	7,87869	9,99999	7,87871	12,12129	34
27	7,89508	9,99999	7,89510	12,10490	33
28	7,91088	9,99999	7,91089	12,08911	32
29	7,92612	9,99998	7,92613	12,07387	31
30	7,94084	9,99998	7,94086	12,05914	30
31	7,95508	9,99998	7,95510	12,04490	29
32	7,96887	9,99998	7,96889	12,03111	28
33	7,98223	9,99998	7,98225	12,01775	27
34	7,99520	9,99998	7,99522	12,00478	26
35	8,00779	9,99998	8,00781	11,99219	25
36	8,02002	9,99998	8,02904	11,97095	24
37	8,03192	9,99997	8,03194	11,96805	23
38	8,04350	9,99997	8,04353	11,95647	22
39	8,05478	9 99997	8,05481	11,94519	21
40	8,06578	9,99997	8,06581	11,93419	20
41	8,07650	9,99997	8,07653	11,92347	19
42	8,08696	9,99997	8,08700	11,91300	18
43	8,09718	9,99997	8,09722	11,90278	17
44	8,10717	9,99996	8,10720	11,89280	16
45	8,11693	9,99996	8,11696	11,88304	15
46	8,12647	9,99996	8,12651	11,87349	14
47	8,13581	9,99996	8,13585	11,86415	13
48	8,14495	9,99996	8,14500	11,85500	12
49	8,15391	9,99996	8,15395	11,84605	11
50	8,16268	9,99995	8,16273	11,83727	10
51	8,17128	9,99995	8,17133	11,82867	9
52	8,17971	9,99995	8,17976	11,82024	8
53	8,18798	9,99995	8,18804	11,81196	7
54	8,19610	9,99995	8,19616	11,80384	6
55	8,20407	9,99994	8,20413	11,79587	5
56	8,21189	9,99994	8,21195	11,78805	4
57	8,21958	9,99994	8,21964	11,78036	3
58	8,22713	9,99994	8,22719	11,77280	2
59	8,23456	9,99994	8,23462	11,76538	1
60	8,24185	9,99993	8,24192	11,75808	0
	Co-ſine	Sine	Co-tan.	Tangent	M

89 Degrees

1 Degree

M	Sine	Co-ſine	Tangent	Co-tang.	
0	8,24185	9,99993	8,24192	11,75808	60
1	8,24903	9,99993	8,24910	11,75090	59
2	8,25609	9,99993	8,25616	11,74383	58
3	8,26304	9,99993	8,26311	11,73688	57
4	8,26988	9,99992	8,26996	11,73004	56
5	8,27661	9,99992	8,27669	11,72331	55
6	8,28324	9,99992	8,28332	11,71668	54
7	8,28977	9,99992	8,28986	11,71014	53
8	8,29621	9,99991	8,29629	11,70371	52
9	8,30255	9,99991	8,30263	11,69737	51
10	8,30879	9,99991	8,30888	11,69112	50
11	8,31495	9,99990	8,31504	11,68495	49
12	8,32103	9,99990	8,32112	11,67888	48
13	8,32702	9,99990	8,32711	11,67289	47
14	8,33292	9,99990	8,33302	11,66697	46
15	8,33875	9,99989	8,33886	11,66114	45
16	8,34450	9,99989	8,34461	11,65539	44
17	8,35018	9,99989	8,35029	11,64971	43
18	8,35578	9,99989	8,35589	11,64410	42
19	8,36131	9,99988	8,36143	11,63857	41
20	8,36678	9,99988	8,36689	11,63310	40
21	8,37217	9,99988	8,37229	11,62771	39
22	8,37750	9,99988	8,37762	11,62238	38
23	8,38276	9,99987	8,38289	11,61711	37
24	8,38796	9,99987	8,38809	11,61191	36
25	8,39310	9,99987	8,39323	11,60677	35
26	8,39818	9,99986	8,39831	11,60168	34
27	8,40320	9,99986	8,40334	11,59666	33
28	8,40816	9,99986	8,40830	11,59170	32
29	8,41307	9,99985	8,41321	11,58679	31
30	8,41792	9,99985	8,41807	11,58193	30
31	8,42272	9,99985	8,42287	11,57713	29
32	8,42746	9,99984	8,42762	11,57238	28
33	8,43216	9,99984	8,43231	11,56768	27
34	8,43680	9,99984	8,43696	11,56304	26
35	8,44139	9,99983	8,44156	11,55844	25
36	8,44594	9,99983	8,44611	11,55389	24
37	8,45044	9,99983	8,45061	11,54939	23
38	8,45489	9,99982	8,45507	11,54493	22
39	8,45930	9,99982	8,45948	11,54052	21
40	8,46366	9,99982	8,46385	11,53615	20
41	8,46798	9,99981	8,46817	11,53183	19
42	8,47226	9,99981	8,47245	11,52755	18
43	8,47650	9,99980	8,47669	11,52331	17
44	8,48069	9,99980	8,48089	11,51911	16
45	8,48485	9,99980	8,48505	11,51495	15
46	8,48896	9,99979	8,48917	11,51083	14
47	8,49304	9,99979	8,49325	11,50675	13
48	8,49708	9,99979	8,49729	11,50271	12
49	8,50108	9,99978	8,50130	11,49870	11
50	8,50504	9,99978	8,50527	11,49473	10
51	8,50897	9,99977	8,50920	11,49080	9
52	8,51287	9,99977	8,51310	11,48690	8
53	8,51673	9,99976	8,51696	11,48304	7
54	8,52055	9,99976	8,52079	11,47921	6
55	8,52434	9,99976	8,52459	11,47541	5
56	8,52810	9,99975	8,52835	11,47165	4
57	8,53183	9,99975	8,53208	11,46792	3
58	8,53552	9,99974	8,53578	11,46422	2
59	8,53919	9,99974	8,53945	11,46055	1
60	8,54282	9,99973	8,54308	11,45692	0
	Co-ſine	Sine	Co-tan.	Tangent	M

88 Degrees

2 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	8,54282	9,99973	8,54308	11,45692	60
1	8,54642	9,99973	8,54669	11,45331	59
2	8,54999	9,99973	8,55027	11,44973	58
3	8,55354	9,99972	8,55382	11,44618	57
4	8,55705	9,99972	8,55734	11,44266	56
5	8,56054	9,99971	8,56083	11,43917	55
6	8,56400	9,99970	8,56429	11,43571	54
7	8,56743	9,99970	8,56773	11,43227	53
8	8,57084	9,99970	8,57114	11,42886	52
9	8,57421	9,99969	8,57452	11,42548	51
10	8,57757	9,99969	8,57788	11,42212	50
11	8,58089	9,99968	8,58121	11,41879	49
12	8,58419	9,99968	8,58451	11,41549	48
13	8,58747	9,99967	8,58779	11,41221	47
14	8,59072	9,99967	8,59105	11,40895	46
15	8,59395	9,99966	8,59428	11,40572	45
16	8,59715	9,99966	8,59749	11,40251	44
17	8,60033	9,99965	8,60068	11,39932	43
18	8,60349	9,99965	8,60384	11,39616	42
19	8,60662	9,99964	8,60698	11,39302	41
20	8,60973	9,99964	8,61009	11,38991	40
21	8,61282	9,99963	8,61319	11,38681	39
22	8,61589	9,99963	8,61626	11,38374	38
23	8,61894	9,99962	8,61931	11,38069	37
24	8,62196	9,99962	8,62234	11,37766	36
25	8,62496	9,99961	8,62535	11,37465	35
26	8,62795	9,99961	8,62834	11,37166	34
27	8,63091	9,99960	8,63131	11,36869	33
28	8,63385	9,99960	8,63426	11,36574	32
29	8,63678	9,99959	8,63718	11,36281	31
30	8,63968	9,99959	8,64009	11,35991	30
31	8,64256	9,99958	8,64298	11,35702	29
32	8,64543	9,99957	8,64585	11,35415	28
33	8,64827	9,99957	8,64870	11,35130	27
34	8,65110	9,99956	8,65154	11,34846	26
35	8,65391	9,99956	8,65435	11,34565	25
36	8,65670	9,99955	8,65715	11,34285	24
37	8,65947	9,99955	8,65993	11,34007	23
38	8,66223	9,99954	8,66269	11,33731	22
39	8,66497	9,99953	8,66543	11,33457	21
40	8,66769	9,99953	8,66816	11,33184	20
41	8,67039	9,99952	8,67087	11,32913	19
42	8,67308	9,99952	8,67356	11,32644	18
43	8,67575	9,99951	8,67624	11,32376	17
44	8,67840	9,99951	8,67890	11,32110	16
45	8,68104	9,99950	8,68154	11,31846	15
46	8,68366	9,99949	8,68417	11,31583	14
47	8,68627	9,99949	8,68678	11,31322	13
48	8,68886	9,99948	8,68938	11,31062	12
49	8,69144	9,99947	8,69169	11,30804	11
50	8,69400	9,99947	8,69453	11,30547	10
51	8,69654	9,99946	8,69708	11,30292	9
52	8,69907	9,99946	8,69962	11,30038	8
53	8,70159	9,99945	8,70214	11,29786	7
54	8,70409	9,99944	8,70465	11,29535	6
55	8,70658	9,99944	8,70714	11,29286	5
56	8,70905	9,99943	8,70962	11,29038	4
57	8,71151	9,99942	8,71208	11,28792	3
58	8,71395	9,99942	8,71453	11,28546	2
59	8,71638	9,99941	8,71697	11,28303	1
60	8,71880	9,99940	8,71940	11,28060	0
	Co ſine	Sine	Co-tan.	Tangent	M

87 Degrees

3 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	8,71880	9,99940	8,71940	11,28060	60
1	8,72120	9,99940	8,72181	11,27819	59
2	8,72359	9,99939	8,72420	11,27580	58
3	8,72597	9,99938	8,72659	11,27341	57
4	8,72834	9,99938	8,72896	11,27104	56
5	8,73069	9,99937	8,73132	11,26868	55
6	8,73303	9,99936	8,73366	11,26634	54
7	8,73535	9,99936	8,73600	11,26400	53
8	8,73767	9,99935	8,73832	11,26168	52
9	8,73997	9,99934	8,74063	11,25937	51
10	8,74226	9,99934	8,74292	11,25708	50
11	8,74454	9,99933	8,74521	11,25479	49
12	8,74680	9,99932	8,74748	11,25252	48
13	8,74905	9,99931	8,74974	11,25026	47
14	8,75130	9,99931	8,75199	11,24801	46
15	8,75353	9,99930	8,75423	11,24577	45
16	8,75575	9,99929	8,75645	11,24355	44
17	8,75795	9,99929	8,75867	11,24133	43
18	8,76015	9,99928	8,76087	11,23913	42
19	8,76234	9,99927	8,76306	11,23693	41
20	8,76451	9,99926	8,76525	11,23475	40
21	8,76667	9,99926	8,76742	11,23258	39
22	8,76883	9,99925	8,76958	11,23042	38
23	8,77097	9,99924	8,77172	11,22827	37
24	8,77310	9,99923	8,77387	11,22613	36
25	8,77522	9,99923	8,77599	11,22400	35
26	8,77733	9,99922	8,77811	11,22189	34
27	8,77943	9,99921	8,78022	11,21978	33
28	8,78152	9,99920	8,78232	11,21768	32
29	8,78360	9,99920	8,78441	11,21559	31
30	8,78567	9,99919	8,78649	11,21351	30
31	8,78774	9,99918	8,78855	11,21145	29
32	8,78979	9,99917	8,79061	11,20939	28
33	8,79183	9,99917	8,79266	11,20734	27
34	8,79386	9,99915	8,79470	11,20530	26
35	8,79588	9,99915	8,79673	11,20327	25
36	8,79789	9,99914	8,79855	11,20125	24
37	8,79990	9,99913	8,80076	11,19924	23
38	8,80189	9,99913	8,80276	11,19723	22
39	8,80388	9,99912	8,80476	11,19524	21
40	8,80585	9,99911	8,80674	11,19326	20
41	8,80782	9,99910	8,80872	11,19128	19
42	8,80978	9,99909	8,81068	11,18932	18
43	8,81173	9,99909	8,81264	11,18736	17
44	8,81367	9,99908	8,81459	11,18541	16
45	8,81560	9,99907	8,81653	11,18347	15
46	8,81752	9,99906	8,81846	11,18154	14
47	8,81944	9,99905	8,82038	11,17962	13
48	8,82134	9,99904	8,82230	11,17770	12
49	8,82324	9,99904	8,82420	11,17579	11
50	8,82513	9,99903	8,82610	11,17390	10
51	8,82701	9,99902	8,82799	11,17201	9
52	8,82888	9,99901	8,82987	11,17013	8
53	8,83075	9,99900	8,83175	11,16825	7
54	8,83261	9,99899	8,83361	11,16639	6
55	8,83446	9,99898	8,83547	11,16453	5
56	8,83630	9,99898	8,83732	11,16268	4
57	8,83813	9,99897	8,83916	11,16084	3
58	8,83996	9,99896	8,84100	11,15900	2
59	8,84177	9,99895	8,84282	11,15717	1
60	8,84358	9,99894	8,84464	11,15536	0
	Co-ſine	Sine	Co-tan.	Tangent	M

86 Degrees

4 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	8,84358	9,99894	8,84464	11,15536	60
1	8,84539	9,99893	8,84645	11,15354	56
2	8,84718	9,99892	8,84826	11,15174	58
3	8,84897	9,99891	8,85006	11,14994	57
4	8,85075	9,99890	8,85185	11,14815	56
5	8,85252	9,99890	8,85363	11,14637	55
6	8,85429	9,99889	8,85540	11,14460	54
7	8,85605	9,99888	8,85717	11,14283	53
8	8,85780	9,99887	8,85893	11,14107	52
9	8,85955	9,99886	8,86069	11,13931	51
10	8,86128	9,99885	8,86243	11,13757	50
11	8,86301	9,99884	8,86417	11,13583	49
12	8,86474	9,99883	8,86590	11,13409	48
13	8,86645	9,99882	8,86763	11,13237	47
14	8,86816	9,99881	8,86935	11,13065	46
15	8,86987	9,99880	8,87106	11,12894	45
16	8,87156	9,99879	8,87277	11,12723	44
17	8,87325	9,99878	8,87447	11,12553	43
18	8,87494	9,99878	8,87616	11,12384	42
19	8,87661	9,99877	8,87785	11,12215	41
20	8,87828	9,99876	8,87953	11,12047	40
21	8,87995	9,99875	8,88120	11,11880	39
22	8,88161	9,99874	88,8287	11,11713	38
23	8,88326	9,99873	8,88453	11,11547	37
24	8,88490	9,99872	8,88618	11,11381	36
25	8,88654	9,99871	8,88783	11,11217	35
26	8,88817	9,99870	8,88948	11,11052	34
27	8,88980	9,99869	8,89111	11,10889	33
28	8,89142	9,99868	8,89274	11,10726	32
29	8,89303	9,99867	8,89437	11,10563	31
30	8,89464	9,99866	8,89598	11,10402	30
31	8,89624	9,99865	8,89760	11,10240	29
32	8,89784	9,99864	8,89920	11,10080	28
33	8,89943	9,99863	8,90080	11,09920	27
34	8,90102	9,99862	8,90240	11,09760	26
35	8,90260	9,99861	8,90399	11,09601	25
36	8,90417	9,99860	8,90557	11,09443	24
37	8,90574	9,99859	8,90715	11,09285	23
38	8,90730	9,99858	8,90872	11,09128	22
39	8,90885	9,99857	8,91028	11,08971	21
40	8,91040	9,99856	8,91185	11,08815	20
41	8,91195	9,99855	8,91340	11,08660	19
42	8,91349	9,99854	8,91495	11,08505	18
43	8,91502	9,99853	8,91649	11,08350	17
44	8,91655	9,99852	8,91803	11,08197	16
45	8,91807	9,99851	8,91957	11,08043	15
46	8,91959	9,99849	8,92110	11,07890	14
47	8,92110	9,99848	8,92262	11,07738	13
48	8,92261	9,99847	8,92414	11,07586	12
49	8,92411	9,99846	8,92565	11,07435	11
50	8,92561	9,99845	8,92716	11,07285	10
51	8,92710	9,99844	8,92866	11,07134	9
52	8,92859	9,99843	8,93015	11,06984	8
53	8,93007	9,99842	8,93165	11,06835	7
54	8,93154	9,99841	8,93313	11,06687	6
55	8,93301	9,99840	8,93462	11,06538	5
56	8,93448	9,99839	8,93609	11,06391	4
57	8,93594	9,99838	8,93756	11,06243	3
58	8,93740	9,99837	8,93903	11,06097	2
59	8,93885	9,99835	8,94049	11,05951	1
60	8,94030	9,99834	8,94195	11,05805	0
	Co-ſine	Sine	Co-tan.	Tangent	M

85 Degrees

5 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	8,94030	9,99834	8,94195	11,05805	60
1	8,94174	9,99833	8,94340	11,05660	59
2	8,94317	9,99832	8,94485	11,05515	58
3	8,94461	9,99831	89,4629	11,05370	57
4	8,94603	9,99830	8,94773	11,05227	56
5	8,94746	9,99829	8,94917	11,05083	55
6	8,94887	9,99828	8,95060	11,04940	54
7	8,95029	9,99827	8,95202	11,04798	53
8	8,95170	9,99825	8,95344	11,04656	52
9	8,95310	9,99824	8,95486	11,04514	51
10	8,95450	9,99823	8,95627	11,04373	50
11	8,95590	9,99823	8,95767	11,04233	49
12	8,95728	9,99822	8,95907	11,04092	48
13	8,95867	9,99820	8,96047	11,03953	47
14	8,96005	9,99819	8,96187	11,03813	46
15	8,96143	9,99817	8,96325	11,03674	45
16	8,96280	9 99816	8,96464	11,03536	44
17	8,96417	9,99815	8,96602	11,03398	43
18	8,96553	9,99814	8,96739	11,03261	42
19	8,96689	9,99813	8,96877	11,03123	41
20	8,96825	9,99812	8,97013	11,02987	40
21	8,96960	9,99810	8,97150	11,02850	39
22	8,97095	9,99809	8,97285	11,02714	38
23	8,97229	9,99808	8,97421	11,02579	37
24	8,97363	9,99807	8,97556	11,02444	36
25	8,97496	9,99806	8,97691	11,02309	35
26	8,97629	9,99804	8,97825	11,02175	34
27	8,97762	9,99803	8,97959	11,02041	33
28	8,97894	9,99802	8,98092	11,01908	32
29	8,98026	9,99801	8,98225	11,01775	31
30	8,98157	9,99800	8,98358	11,01642	30
31	8,98288	9,99798	8,98490	11,01510	29
32	8,98419	9,99797	8,98622	11,01378	28
33	8,98559	9,99796	8,98753	11,01247	27
34	8,98688	9,99795	8,98884	11,01186	26
35	8,98818	9,99793	8,99015	11,00985	25
36	8,98947	9,99792	8,99145	11,00855	24
37	8,99066	9,99791	8,99275	11,00725	23
38	8,99194	9,99790	8,99404	11,00595	22
39	8,99322	9,99788	8,99534	11,00466	21
40	8,99450	9,99787	8,99662	11,00338	20
41	8,99577	9,99786	8,99791	11,00209	19
42	8,99704	9,99785	8,99919	11,00081	18
43	8,99830	9,99783	9,00046	10,99953	17
44	8,99956	9,99782	9,00174	10,99826	16
45	9,00082	9,99781	9,00301	10,99699	15
46	9,00207	9,99780	9,00427	10,99573	14
47	9,00332	9,99778	9,00553	10,99447	13
48	9,00456	9,99777	9,00679	10,99321	12
49	9,00580	9,99776	9,00805	10,99195	11
50	9,00704	9,99774	9,00930	10,99070	10
51	9,00828	9,99773	9,01055	10,98945	9
52	9,00951	9,99772	9,01179	10,98821	8
53	9,01074	9,99771	9,01303	10,98697	7
54	9,01196	9,99769	9,01427	10,98573	6
55	9,01318	9,99768	9,01550	10,98450	5
56	9,01440	9,99767	9,01673	10,98327	4
57	9,01561	9,99765	9,01796	10,98204	3
58	9,01682	9,99764	9,01918	10,98082	2
59	9,01803	9,99763	9,02040	10,97960	1
60	9,01923	9,99761	9,02162	10,97838	0
	Co-ſine	Sine	Co-tan.	Tangent	M

84 Degrees

6 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,01923	9,99761	9,02162	10,97838	60
1	9,02043	9,99760	9,02283	10,97717	59
2	9,02163	9,99759	9,02404	10,97596	58
3	9,02282	9,99757	9,02525	10,97475	57
4	9,02402	9,99756	9,02645	10,97354	56
5	9,02520	9,99755	9,02765	10,97234	55
6	9,02639	9,99753	9,02885	10,97115	54
7	9,02757	9,99752	9,03005	10,96995	53
8	9,02874	9,99751	9,03124	10,96876	52
9	9,02992	9,99749	9,03242	10,96757	51
10	9,03109	9,99748	9,03361	10,96639	50
11	9,03226	9,99747	9,03479	10,96521	49
12	9,03342	9,99745	9,03597	10,96403	48
13	9,03458	9,99744	9,03714	10,96286	47
14	9,03574	9,99742	9,03832	10,96168	46
15	9,03690	9,99741	9,03948	10,96051	45
16	9,03805	9,99740	9,04065	10,95935	44
17	9,03920	9,99738	9,04181	10,95819	43
18	9,04034	9,99737	9,04297	10,95703	42
19	9,04148	9,99735	9,04413	10,95587	41
20	9,04262	9,99734	9,04528	10,95472	40
21	9,04376	9,99733	9,04643	10,95357	39
22	9,04489	9,99731	9,04758	10,95242	38
23	9,04603	9,99730	9,04873	10,95127	37
24	9,04715	9,99728	9,04987	10,95013	36
25	9,04828	9,99727	9,05101	10,94899	35
26	9,04940	9,99726	9,05214	10,94876	34
27	9,05052	9,99724	9,05328	10,94672	33
28	9,05163	9,99723	9,05441	10,94559	32
29	9,05275	9,99721	9,05553	10,94447	31
30	9,05386	9,99720	9,05666	10,94334	30
31	9,05497	9,99718	9,05778	10,94222	29
32	9,05607	9,99717	9,05890	10,94110	28
33	9,05717	9,99716	9,06002	10,93998	27
34	9,05827	9,99714	9,06113	10,93887	26
35	9,05937	9,99713	9,06224	10,93776	25
36	9,06046	9,99711	9,06335	10,93665	24
37	9,06155	9,99710	9,06445	10,93555	23
38	9,06264	9,99708	9,06556	10,93444	22
39	9,06372	9,99707	9,06665	10,93334	21
40	9,06481	9,99705	9,06775	10,93225	20
41	9,06588	9,99704	9,06885	10,93115	19
42	9,06696	9,99702	9,06994	10,93006	18
43	9,06804	9,99701	9,07103	10,92897	17
44	9,06911	9,99699	9,07211	10,92789	16
45	9,07018	9,99698	9,07320	10,92680	15
46	9,07124	9,99696	9,07428	10,92572	14
47	9,07230	9,99695	9,07536	10,92464	13
48	9,07337	9,99693	9,07643	10,92357	12
49	9,07442	9,99692	9,07750	10,92249	11
50	9,07548	9,99690	9,07858	10,92142	10
51	9,07653	9,99689	9,07964	10,92036	9
52	9,07758	9,99687	9,08071	10,91929	8
53	9,07863	9,99686	9,08177	10,91823	7
54	9,07968	9,99684	9,08283	10,91717	6
55	9,08072	9,99683	9,08389	10,91611	5
56	9,08176	9,99681	9,08495	10,91505	4
57	9,08280	9,99680	9,08601	10,91400	3
58	9,08383	9,99678	9,08705	10,91295	2
59	9,08486	9,99677	9,08810	10,91190	1
60	9,08589	9,99675	9,08914	10,9 086	0
	Co-ſine	Sine	Co-tan.	Tangent	M

83 Degrees

7 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,08589	9,99675	9,08914	10,91086	60
1	9,08692	9,99673	9,09019	10,90981	59
2	9,08795	9,99672	9,09123	10,90877	58
3	9,08897	9,99670	9,09227	10,90773	57
4	9,08999	9,99669	9,09330	10,90670	56
5	9,09101	9,99667	9,09433	10,90566	55
6	9,09202	9,99666	9,09537	10,90463	54
7	9,09304	9,99664	9,09640	10,90360	53
8	9,09405	9,99662	9,09742	10,90258	52
9	9,09506	9,99661	9,09845	10,90155	51
10	9,09606	9,99659	9,09947	10,90053	50
11	9,09706	9,99658	9,10049	10,89951	49
12	9,09807	9,99656	9,10150	10,89849	48
13	9,09906	9,99655	9,10252	10,89748	47
14	9,10006	9,99653	9,10353	10,89647	46
15	9,10106	9,99651	9,10454	10,89546	45
16	9,10205	9,99650	9,10555	10,89445	44
17	9,10304	9,99648	9,10656	10,89344	43
18	9,10402	9,99646	9,10756	10,89244	42
19	9,10501	9,99645	9,10856	10,89144	41
20	9,10599	9,99643	9,10956	10,89044	40
21	9,10697	9,99642	9,11056	10,88944	39
22	9,10795	9,99640	9,11155	10,88845	38
23	9,10893	9,99638	9,11254	10,88746	37
24	9,10990	9,99637	9,11353	10,88647	36
25	9,11087	9,99635	9,11452	10,88548	35
26	9,11184	9,99633	9,11551	10,88449	34
27	9,11121	9,99632	9,11649	10,88351	33
28	9,11377	9,99630	9,11747	10,88253	32
29	9,11474	9,99628	9,11845	10,88155	31
30	9,11570	9,99627	9,11943	10,88057	30
31	9,11666	9,99625	9,12040	10,87960	29
32	9,11761	9,99623	9,12138	10,87862	28
33	9,11857	9,99622	9,12235	10,87765	27
34	9,11952	9,99620	9,12332	10,87668	26
35	9,12047	9,99618	9,12428	10,87572	25
36	9,12142	9,99617	9,12525	10,87475	24
37	9,12236	9,99615	9,12621	10,87379	23
38	9,12331	9,99613	9,12717	10,87283	22
39	9,12425	9,99612	9,12813	10,87187	21
40	9,12519	9,99610	9,12909	10,87091	20
41	9,12612	9,99608	9,13004	10,86996	19
42	9,12706	9,99607	9,13099	10,86901	18
43	9,12799	9,99605	9,13194	10,86806	17
44	9,12892	9,99603	9,13289	10,86711	16
45	9,12985	9,99601	9,13384	10,86616	15
46	9,13078	9,99600	9,13478	10,86522	14
47	9,13171	9,99598	9,13573	10,86427	13
48	9,13263	9,99596	9,13667	10,86333	12
49	9,13355	9,99595	9,13760	10,86239	11
50	9,13447	9,99593	9,13854	10,86146	10
51	9,13539	9,99591	9,13948	10,86052	9
52	9,13630	9,99589	9,14041	10,85959	8
53	9,13722	9,99588	9,14134	10,85866	7
54	9,13813	9,99586	9,14227	10,85773	6
55	9,13904	9,99584	9,14320	10,85680	5
56	9,13994	9,99582	9,14412	10,85588	4
57	9,14085	9,99581	9,14504	10,85496	3
58	9,14175	9,99579	9,14596	10,85403	2
59	9,14265	9,99577	9,14688	10,85311	1
60	9,14355	9,99575	9,14780	10,85220	0
	Co-ſine	Sine	Co-tan.	Tangent	M

82 Degrees

8 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,14355	9,99575	9,14780	10,85220	60
1	9,14445	9,99573	9,14872	10,85128	59
2	9,14535	9,99572	9,14963	10,85037	58
3	9,14624	9,99570	9,15054	10,84946	57
4	9,14714	9,99568	9,15145	10,84855	56
5	9,14803	9,99566	9,15236	10,84764	55
6	9,14891	9,99565	9,15327	10,84673	54
7	9,14980	9,99563	9,15417	10,84583	53
8	9,15069	9,99561	9,15508	10,84492	52
9	9,15157	9,99559	9,15598	10,84402	51
10	9,15245	9,99557	9,15688	10,84312	50
11	9,15333	9,99555	9,15777	10,84222	49
12	9,15421	9,99554	9,15867	10,84133	48
13	9,15508	9,99552	9,15956	10,84043	47
14	9,15596	9,99550	9,16046	10,83954	46
15	9,15683	9,99548	9,16135	10,83865	45
16	9,15770	9,99546	9,16224	10,83776	44
17	9,15857	9,99544	9,16312	10,83688	43
18	9,15943	9,99543	9,16401	10,83599	42
19	9,16030	9,99541	9,16489	10,83511	41
20	9,16116	9,99539	9,16577	10,83423	40
21	9,16202	9,99537	9,16665	10,83335	39
22	9,16288	9,99535	9,16753	10,83247	38
23	9,16374	9,99533	9,16841	10,83159	37
24	9,16460	9,99532	9,16928	10,83072	36
25	9,16545	9,99530	9,17016	10,82984	35
26	9,16631	9,99528	9,17103	10,82897	34
27	9,16716	9,99526	9,17189	10,82810	33
28	9,16801	9,99524	9,17277	10,82723	32
29	9,16886	9,96522	9,17363	10,82637	31
30	9,16970	9,99520	9,17450	13,82550	30
31	9,17055	9,99518	9,17536	10,82464	29
32	9,17139	9,99516	9,17622	10,82378	28
33	9,17223	9,99515	9,17708	10,82292	27
34	9,17307	9,99513	9,17794	10,82206	26
35	9,17391	9,99511	9,17880	10,82120	25
36	9,17474	9,99509	9,17965	10,82034	24
37	9,17558	9,99507	9,18051	10,81949	23
38	9,17641	9,99505	9,18136	10,81864	22
39	9,17724	9,99503	9,18221	10,81779	21
40	9,17807	9,99501	9,18306	10,81694	20
41	9,17890	9,99499	9,18391	10,81609	19
42	9,17973	9,99497	9,18475	80,81525	18
43	9,18055	9,99495	9,18560	10,81440	17
44	9,18137	9,99493	9,18644	10,81356	16
45	9,18220	9,99492	9,18728	10,81272	15
46	9,18302	9,99490	9,18812	10,81188	14
47	9,18383	9,99488	9,18896	10,81104	13
48	9,18465	9,99486	9,18979	10,81021	12
49	9,18547	9,99484	9,19063	10,80937	11
50	9,18628	9,99482	9,19146	10,80854	10
51	9,18709	9,99480	9,19229	10,80771	9
52	9,18790	9,99478	9,19312	10,80688	8
53	9,18871	9,99476	9,19395	10,80605	7
54	9,18952	9,99474	9,19478	10,80522	6
55	9,19032	9,99473	9,19561	10,80439	5
56	9,19113	9,99470	9,19643	10,80357	4
57	9,19193	9,99468	9,19725	10,80275	3
58	9,19273	9,99466	9,19807	10,80193	2
59	9,19353	9,99464	9,19889	10,80111	1
60	9,19433	9,99462	9,19971	10,80029	0
	Co-ſine	Sine	Co-tan.	Tangent	M

81 Degrees

9 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,19433	9,99462	9,19971	10,80029	60
1	9,19513	9,99460	9,20053	10,79947	59
2	9,19592	9,99458	9,20134	10,79865	58
3	9,19672	9,99456	9,20216	10,79784	57
4	9,19751	9,99454	9,20297	10,79703	56
5	9,19830	9,99452	9,20378	10,79621	55
6	9,19909	9,99450	9,20459	10,79541	54
7	9,19988	9,99448	9,20540	10,79460	53
8	9,20067	9,99446	9,20621	10,79379	52
9	9,20145	9,99444	9,20701	10,79298	51
10	9,20223	9,99442	9,20782	10,79218	50
11	9,20302	9,99440	9,20862	10,79138	49
12	9,20380	9,99438	9,20942	10,79058	48
13	9,20458	9,99436	9,21022	10,78978	47
14	9,20535	9,99434	9,21102	10,78898	46
15	9,20613	9,99432	9,21181	10,78818	45
16	9,20691	9,99429	9,21261	10,78739	44
17	9,20768	9,99427	9,21340	10,78659	43
18	9,20845	9,99425	9,21420	10,78580	42
19	9,20922	9,99423	9,21499	10,78501	41
20	9,20999	9,99421	9,21578	10,78422	40
21	9,21076	9,99419	9,21657	10,78343	39
22	9,21153	9,99417	9,21736	10,78264	38
23	9,21229	9,99415	9,21814	10,78186	37
24	9,21305	9,99413	9,21893	10,78107	36
25	9,21382	9,99410	9,21971	10,78029	35
26	9,21458	9,99409	9,22049	10,77951	34
27	9,21534	9,99407	9,22127	10,77873	33
28	9,21610	9,99404	9,22205	10,77795	32
29	9,21685	9,99402	9,22283	10,77717	31
30	9,21761	9,99400	9,22361	10,77639	30
31	9,21836	9,99398	9,22438	10,77562	29
32	9,21912	9,99396	9,22516	10,77484	28
33	9,21987	9,99394	9,22593	10,77407	27
34	9,22062	9,99392	9,22670	10,77330	26
35	9,22137	9,99390	9,22747	10,77253	25
36	9,22211	9,99387	9,22824	10,77176	24
37	9,22286	9,99385	9,22901	10,77099	23
38	9,22361	9,99383	9,22977	10,77022	22
39	9,22435	9,99381	9,23054	10,76946	21
40	9,22509	9,99379	9,23131	10,76870	20
41	9,22583	9,99377	9,23206	10,76793	19
42	9,22657	9,89375	9,23283	10,76717	18
43	9,22731	9,99372	9,23359	10,76641	17
44	9,22805	9,99370	9,23434	10,76565	16
45	9,22878	9,99368	9,23510	10,76490	15
46	9,22952	9,99366	9,23586	10,76414	14
47	9,23025	9,99364	9,23661	10,76339	13
48	9,23098	9,99362	9,23737	10,76263	12
49	9,23171	9,99359	9,23812	10,76188	11
50	9,23244	9,99357	9,23887	10,76113	10
51	9,23317	9,99355	9,23962	10,76038	9
52	9,23390	9,99353	9,24037	10,75963	8
53	9,23462	9,99351	9,24112	10,75888	7
54	9,23535	9,99348	9,24186	10,75813	6
55	9,23607	9,99346	9,24261	10,75739	5
56	9,23679	9,99344	9,24335	10,75665	4
57	9,23751	9,99342	9,24410	10,75590	3
58	9,23823	9,99340	9,24484	10,75516	2
59	9,23895	9,99337	9,24558	10,75442	1
60	9,23967	9,99335	9,24632	10,75368	0
	Co-ſine	Sine	Co-tan.	Tangent	M

80 Degrees

10 Degree

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,23967	9,99335	9,24632	10,75368	60
1	9,24039	9,99333	9,24706	10,75294	59
2	9,24110	9,99331	9,24779	10,75221	58
3	9,24181	9,99328	9,24853	10,75147	57
4	9,24253	9,99326	9,24926	10,75074	56
5	9,24324	9,99324	9,25000	10,75000	55
6	9,24395	9,99322	9,25073	10,74927	54
7	9,24466	9,99319	9,25146	10,74854	53
8	9,24536	9,99317	9,25219	10,74781	52
9	9,24607	9,99315	9,25292	10,74708	51
10	9,24677	9,99313	9,25365	10,74635	50
11	9,24748	9,99310	9,25437	10,74563	49
12	9,24818	9,99308	9,25510	10,74490	48
13	9,24888	9,99306	9,25582	10,74418	47
14	9,24958	9,99304	9,25655	10,74345	46
15	9,25028	9,99301	9,25727	10,74273	45
16	9,25098	9,99299	9,25799	10,74201	44
17	9,25168	9,99297	9,25871	10,74129	43
18	9,25237	9,99294	9,25943	10,74057	42
19	9,25307	9,99292	9,26015	10,73985	41
20	9,25376	9,99290	9,26086	10,73914	40
21	9,25445	9,99287	9,26158	10,73842	39
22	9,25514	9,99285	9,26229	10,73771	38
23	9,25583	9,99283	9,26300	10,73699	37
24	9,25652	9,99281	9,26372	10,73628	36
25	9,25721	9,99278	9,26443	10,73557	35
26	9,25790	9,99276	9,26514	10,73486	34
27	9,25858	9,99274	9,26585	10,73415	33
28	9,25927	9,99271	9,26655	10,73344	32
29	9,25995	9,99269	9,26726	10,73274	31
30	9,26063	9,99267	9,26797	10,73203	30
31	9,26131	9,99264	9,26867	10,73133	29
32	9,26199	9,99262	9,26937	10,73063	28
33	9,26267	9,99260	9,27008	10,72992	27
34	9,26335	9,99257	9,27078	10,72922	26
35	9,26403	9,99255	9,27148	10,72852	25
36	9,26470	9,99252	9,27218	10,72782	24
37	9,26538	9,99250	9,27288	10,72712	23
38	9,26605	9,99248	9,27357	10,72643	22
39	9,26672	9,99245	9,27427	10,72573	21
40	9,26739	9,99243	9,27496	10,72504	20
41	9,26806	9,99241	9,27566	10,72434	19
42	9,26873	9,99238	9,27635	10,72365	18
43	9,26940	9,99236	9,27704	10,72296	17
44	9,27007	9,99233	9,27773	10,72227	16
45	9,27073	9,99231	9,27842	10,72158	15
46	9,27140	9,99229	9,27911	10,72089	14
47	9,27206	9,99226	9,27980	10,72020	13
48	9,27273	9,99224	9,28049	10,71951	12
49	9,27339	9,99221	9,28117	10,71883	11
50	9,27405	9,99219	9,28186	10,71814	10
51	9,27471	9,99217	9,28254	10,71746	9
52	9,27537	9,99214	9,28322	10,71677	8
53	9,27602	9,99212	9,28391	10,71609	7
54	9,27668	9,99209	9,28459	10,71541	6
55	9,27734	9,99207	9,28527	10,71473	5
56	9,27799	9,99204	9,28595	10,71405	4
57	9,27864	9,99202	9,28662	10,71337	3
58	9,27930	9,99200	9,28730	10,71270	2
59	9,27995	9,99197	9,28798	10,71202	1
60	9,28060	9,99195	9,28865	10,71135	0
	Co-ſine	Sine	Co-tan.	Tangent	M

79 Degrees

11 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,28060	9,99195	9,28865	10,71135	60
1	9,28125	9,99192	9,28933	10,71067	59
2	9,28190	9,99190	9,29000	10,71000	58
3	9,28254	9,99187	9,29067	10,70933	57
4	9,28319	9,99185	9,29134	10,70866	56
5	9,28384	9,99182	9,29201	10,70799	55
6	9,28448	9,99180	9,29268	10,70732	54
7	9,28512	9,99177	9,29335	10,70665	53
8	9,28577	9,99175	9,29402	10,70598	52
9	9,28641	9,99172	9,29468	10,70532	51
10	9,28705	9,99170	9,29535	10,70465	50
11	9,28769	9,99167	9,29601	10,70399	49
12	9,28833	9,99165	9,29668	10,70332	48
13	9,28896	9,99162	9,29734	10,70266	47
14	9,28960	9,99160	9,29800	10,70200	46
15	9,29024	9,99157	9,29866	10,70134	45
16	9,29087	9,99155	9,29932	10,70068	44
17	9,29150	9,99152	9,29998	10,70002	43
18	9,29214	9,99150	9,30064	10,69936	42
19	9,29277	9,99147	9,30129	10,69870	41
20	9,29340	9,99145	9,30195	10,69805	40
21	9,29403	9,99142	9,30261	10,69739	39
22	9,29466	9,99140	9,30326	10,69674	38
23	9,29529	9,99137	9,30391	10,69609	37
24	9,29591	9,99135	9,30457	10,69543	36
25	9,29654	9,99132	9,30522	10,69478	35
26	9,29716	9,99129	9,30587	10,69413	34
27	9,29779	9,99127	9,30652	10,69348	33
28	9,29841	9,99124	9,30717	10,69283	32
29	9,29903	9,99122	9,30781	10,69218	31
30	9,29965	9,99119	9,30846	10,69154	30
31	9,30028	9,99117	9,30911	10,69089	29
32	9,30089	9,99114	9,30975	10,69025	28
33	9,30151	9,99111	9,31040	10,68960	27
34	9,30213	9,99109	9,31104	10,68896	26
35	9,30275	9,99106	9,31168	10,68831	25
36	9,30336	9,99104	9,31233	10,68767	24
37	9,30398	9,99101	9,31297	10,68703	23
38	9,30459	9,99099	9,31361	10,68639	22
39	9,30521	9,99096	9,31425	10,68575	21
40	9,30582	9,99093	9,31488	10,68511	20
41	9,30643	9,99091	9,31552	10,68448	19
42	9,30704	9,99088	9,31616	10,68384	18
43	9,30765	9,99085	9,31679	10,68320	17
44	9,30826	9,99083	9,31743	10,68257	16
45	9,30887	9,99080	9,31806	10,68194	15
46	9,30947	9,99078	9,31870	0,68130	14
47	9,31008	9,99075	9,31933	10,68067	13
48	9,31068	9,99072	9,31996	10,68004	12
49	9,31129	9,99070	4,32059	10,67941	11
50	9,31189	9,99067	9,32122	10,67878	10
51	9,31249	9,99064	9,32185	10,67815	9
52	9,31310	9,99062	9,32248	10,67752	8
53	9,31370	9,99059	9,32311	10,67689	7
54	9,31430	9,99056	9,32373	10,67627	6
55	9,31490	9,99054	9,32436	10,67564	5
56	9,31549	9,99051	9,32498	10,67502	4
57	9,31609	9,99048	9,32561	10,67439	3
58	9,31669	9,99045	9,32623	10,67377	2
59	9,31728	9,99043	9,32685	10,67315	1
60	9,31788	9,99040	9,32747	10,67252	0
	Co-ſine	Sine	Co-tan.	Tangent	M

78 Degrees

12 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,31788	9,99040	9,32747	10,67252	60
1	9,31847	9,99038	9,32809	10,67190	59
2	9,31907	9,99035	9,32871	10,67128	58
3	9,31966	9,99032	9,32933	10,67066	57
4	9,32025	9,99030	9,32995	10,67005	56
5	9,32084	9,99027	9,33057	10,66994	55
6	9,32143	9,99024	9,33119	10,66881	54
7	9,33202	9,99021	9,33180	10,66820	53
8	9,32261	9,99019	9,33242	10,66758	52
9	9,32319	9,99016	9,33303	10,66697	51
10	9,32378	9,99013	9,33365	10,66635	50
11	9,32437	9,99010	9,33426	10,66574	49
12	9,32495	9,99008	9,33487	10,66513	48
13	9,32553	9,99005	9,33548	10,66452	47
14	9,32612	9,99002	9,33609	10,66391	46
15	9,32670	9,99000	9,33670	10,66330	45
16	9,32728	9 98997	9,33731	10,66269	44
17	9,32786	9,98994	9,33792	10,66208	43
18	9,32844	9,98991	9,33853	10,66147	42
19	9,32002	9,98989	9,33913	10,66087	41
20	9,32960	9,98986	9,33974	10,66026	40
21	9,33018	9,98983	9,34034	10,65966	39
22	9,33075	9,98980	9,34095	10,65905	38
23	9,33133	9,98978	9,34155	10,65845	37
24	9,33190	9,98975	9,34215	10,65784	36
25	9,33248	9,98972	9,34276	10,65724	35
26	9,33305	9,98969	9,34336	10,65664	34
27	9,33362	9,98966	9,34396	10,65604	33
28	9,33419	9,98964	9,34456	10,65544	32
29	9,33477	9,98961	9,34516	10,65484	31
30	9,33534	9,98958	9,34575	10,65424	30
31	9,33591	9,98955	9,34635	10,65365	29
32	9,33647	9,98952	9,34695	10,65305	28
33	9,33704	9,98950	9,34754	10,65245	27
34	9,33761	9,98947	9,34814	10,65186	26
35	9,33818	9,98944	9,34873	10,65121	25
36	9,33874	9,98941	9,34933	10,65067	24
37	9,33931	9,98938	9,34992	10,65008	23
38	9,33987	9,98936	9,35051	10,64949	22
39	9,34043	9,98933	9,35111	10,64889	21
40	9,34100	9,98930	9,35170	10,64830	20
41	9,34156	9,98927	9,35229	10,64771	19
42	9,34212	9,98924	9,35288	10,64712	18
43	9,34268	9,98921	9,35346	10,64653	17
44	9,34324	9,98919	9,35405	10,64595	16
45	9,34380	9,98916	9,35464	10,64536	15
46	9,34435	9,98913	9,35523	10,64478	14
47	9,34491	9,98910	9,35581	10,64419	13
48	9,34547	9,98907	9,35640	10,64360	12
49	9,34602	9,98904	9,35698	10,64302	11
50	9,34658	9,98901	9,35757	10,64243	10
51	9,34713	9,98898	9,35815	10,64185	9
52	9,34769	9,98896	9,35873	10,64127	8
53	9,34824	9,98893	9,35931	10,64069	7
54	9,34879	9,98890	9,35989	10,64011	6
55	9,34934	9,98887	9,36047	10,63953	5
56	9,34989	9,98884	9,36105	10,63895	4
57	9,35044	9,98881	9,36163	10,63837	3
58	9,35099	9,98878	9,36221	10,63779	2
59	9,35154	9,98875	9,36279	10,63721	1
60	9,35209	9,98872	9,36336	10,63664	0
	Co-ſine	Sine	Co-tan.	Tangent	M

77 Degrees

13 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,35209	9,98872	9,36336	10,63664	60
1	9,35263	9,98869	9,36394	10,63606	59
2	9,35318	9,98866	9,36451	10,63548	58
3	9,35373	9,98864	9,36509	10,63491	57
4	9,35427	9,98861	9,36566	10,63434	56
5	9,35481	9,98858	9,36624	10,63376	55
6	9,35536	9,98855	9,36681	10,63319	54
7	9,35590	9,98852	9,36738	10,63262	53
8	9,35644	9,98849	9,36795	10,63205	52
9	9,35698	9,98846	9,36852	10,63148	51
10	9,35752	9,98843	9,36909	10,63091	50
11	9,35806	9,98840	9,36966	10,63034	49
12	9,35860	9,98837	9,37023	10,62977	48
13	9,35914	9,98834	9,37080	10,62920	47
14	9,35968	9,98831	9,37137	10,62863	46
15	9,36021	9,98828	9,37193	10,62807	45
16	9,36075	9,98825	9,37250	10,62750	44
17	9,36129	9,98822	9,37306	10,62693	43
18	9,36182	9,98819	9,37363	10,62637	42
19	9,36236	9,98816	9,37419	10,62581	41
20	9,36289	9,98813	9,37476	10,62524	40
21	9,36342	9,98810	9,37532	10,62468	39
22	9,36395	9,98807	9,37588	10,62412	38
23	9,36448	9,98804	9,37644	10,62356	37
24	9,36502	9,98801	9,37700	10,62300	36
25	9,36555	9,98798	9,37756	10,62244	35
26	9,36607	9,98795	9,37812	10,62188	34
27	9,36660	9,98792	9,37868	10,62132	33
28	9,36713	9,98789	9,37924	10,62076	32
29	9,36766	9,98786	9,37980	10,62020	31
3	9,36818	9,98783	9,38035	10,61965	30
31	9,36871	9,98780	9,38091	10,61909	29
32	9,36924	9,98777	9,38146	10,61853	28
33	9,36976	9,98774	9,38202	10,61798	27
34	9,37028	9,98771	9,38257	10,61742	26
35	9,37081	9,98768	9,38312	10,61687	25
36	9,37133	9,98765	9,38368	10,61632	24
37	9,37185	9,98762	9,38423	10,61577	23
38	9,37237	9,98759	9,38479	10,61521	22
39	9,37289	9,98756	9,38534	10,61466	21
40	9,37341	9,98753	9,38589	10,61411	20
41	9,37393	9,98749	9,38644	10,61356	19
42	9,37445	9,98746	9,38699	10,61301	18
43	9,37497	9,98743	9,38754	10,61246	17
44	9,37549	9,98740	9,38808	10,61192	16
45	9,37600	9,98737	9,38863	10,61137	15
46	9,37652	9,98734	9,38918	10,61082	14
47	9,37704	9,98731	9,38972	10,61028	13
48	9,37755	9,98728	9,39028	10,60973	12
49	9,37806	9,98725	9,39081	10,60918	11
50	9,37858	9,98722	9,39136	10,60864	10
51	9,37908	9,98719	9,39190	10,60810	9
52	9,37960	9,98715	9,39245	10,60755	8
53	9,38011	9,98712	9,39299	10,60701	7
54	9,38062	9,98709	9,39353	10,60645	6
55	9,38113	9,98706	9,39407	10,60593	5
56	9,38164	9,98703	9,39461	10,60539	4
57	9,38215	9,98700	9,39515	10,60484	3
58	9,38266	9,98697	9,39569	10,60431	2
59	9,38317	9,98694	9,39623	10,60377	1
60	9,38367	9,98690	9,39677	10,60323	0
	Co-ſine	Sine	Co-tan.	Tangent	M

76 Degrees

14 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,38367	9,98690	9,39677	10,60323	60
1	9,38418	9,98687	9,39731	10,60269	59
2	9,38469	9,98684	9,39785	10,60215	58
3	9,38519	9,98681	9,39838	10,60162	57
4	9,38570	9,98678	9,39892	10,60108	56
5	9,38620	9,98675	9,39945	10,60054	55
6	9,38670	9,98671	9,39999	10,60001	54
7	9,38721	9,98668	9,40052	10,59948	53
8	9,38771	9,98665	9,40106	10,59894	52
9	9,38821	9,98662	9,40159	10,59840	51
10	9,38871	9,98659	9,40212	10,59788	50
11	9,38921	9,98655	9,40266	10,59734	49
12	9,38971	9,98652	9,40319	10,59681	48
13	9,39021	9,98649	9,40372	10,59628	47
14	9,39071	9,98646	9,40425	10,59575	46
15	9,39121	9,98643	9,40478	10,59522	45
16	9,39170	9,98639	9,40531	10,59469	44
17	9,39220	9,98636	9,40584	10,59416	43
18	9,39269	9,98633	9,40636	10,59363	42
19	9,39319	9,98630	9,40689	10,59311	41
20	9,39368	9,98627	9,40742	10,59258	40
21	9,39418	9,98623	9,40794	10,59205	39
22	9,39467	9,98620	9,40847	10,59153	38
23	9,39517	9,98617	9,40900	10,59100	37
24	9,39566	9,98614	9,40952	10,59048	36
25	9,39615	9,98610	9,41004	10,58995	35
26	9,39664	9,98607	9,41057	10,58943	34
27	9,39713	9,98604	9,41109	10,58891	33
28	9,39762	9,98601	9,41161	10,58838	32
29	9,39811	9,98597	9,41214	10,58786	31
30	9,39860	9,98594	9,41266	10,58734	30
31	9,39909	9,98591	9,41318	10,58682	29
32	9,39957	9,98588	9,41370	10,58630	28
33	9,40006	9,98584	9,41422	10,58578	27
34	9,40055	9,98581	9,41474	10,58526	26
35	9,40103	9,98578	9,41526	10,58474	25
36	9,40152	9,98574	9,41577	10,58422	24
37	9,40200	9,98571	9,41629	10,58371	23
38	9,40249	9,98568	9,41681	10,58319	22
39	9,40297	9,98565	9,41733	10,58267	21
40	9,40345	9,98561	9,41784	10,58216	20
41	9,40394	9,98558	9,41836	10,58164	19
42	9,40442	9,98555	9,41887	10,58113	18
43	9,40490	9,98551	9,41939	10,58061	17
44	9,40538	9,98548	9,41990	10,58010	16
45	9,40586	9,98545	9,42041	10,57958	15
46	9,40634	9,98541	9,42093	10,57907	14
47	9,40682	9,98538	9,42144	10,57856	13
48	9,40730	9,98535	9,42195	10,57805	12
49	9,40778	9,98531	9,42246	10,57754	11
50	9,40825	9,98528	9,42297	10,57703	10
51	9,40873	9,98525	9,42348	10,57652	9
52	9,40921	9,98521	9,42399	10,57601	8
53	9,40968	9,98518	9,42450	10,57550	7
54	9,41016	9,98515	9,42501	10,57499	6
55	9,41063	9,98511	9,42552	10,57448	5
56	9,41111	9,98508	9,42603	10,57397	4
57	9,41158	9,98504	9,42653	10,57347	3
58	9,41205	9,98501	9,42704	10,57296	2
59	9,41252	9,98498	9,42755	10,57245	1
60	9,41300	9,98494	9,42805	10,57195	0
	Co-ſine	Sine	Co-tan.	Tangent	M

75 Degrees

15 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,41300	9,98494	9,42805	10,57195	60
1	9,41347	9,98491	9,42856	10,57144	59
2	9,41394	9,98488	9,42906	10,57094	58
3	9,41441	9,98484	9,42957	10,57043	57
4	9,41488	9,98481	9,43007	10,56993	56
5	9,41535	9,98477	9,43057	10,56943	55
6	9,41581	9,98474	9,43107	10,56892	54
7	9,41628	9,98471	9,43158	10,56842	53
8	9,41675	9,98467	9,43208	10,56792	52
9	9,41722	9,98464	9,43258	10,56742	51
10	9,41768	9,98460	9,43308	10,56692	50
11	9,41815	9,98457	9,43358	10,56642	49
12	9,41861	9,98453	9,43408	10,56592	48
13	9,41908	9,98450	9,43458	10,56542	47
14	9,41954	9,98447	9,43508	10,56492	46
15	9,42001	9,98443	9,43558	10,56442	45
16	9,42047	9,98440	9,43607	10,56393	44
17	9,42093	9,98436	9,43657	10,56343	43
18	9,42139	9,98433	9,43707	10,56293	42
19	9,42186	9,98429	9,43756	10,56244	41
20	9,42232	9,98426	9,43806	10,56194	40
21	9,42278	9,98422	9,43855	10,56145	39
22	9,42324	9,98419	9,43905	10,56095	38
23	9,42370	9,98415	9,43954	10,56046	37
24	9,42416	9,98412	9,44004	10,55996	36
25	9,42461	9,98408	9,44053	10,55947	35
26	9,42507	9,98405	9,44102	10,55898	34
27	9,42553	9,98401	9,44151	10,55848	33
28	9,42599	9,98398	9,44201	10,55799	32
29	9,42644	9,98394	9,44250	10,55750	31
30	9,42690	9,98391	9,44299	10,55701	30
31	9,42735	9,98387	9,44348	10,55652	29
32	9,42781	9,98384	9,44397	10,55603	28
33	9,42826	9,98380	9,44446	10,55554	27
34	9,42872	9,98377	9,44495	10,55505	26
35	9,42917	9,98373	9,44543	10,55456	25
36	9,42962	9,98370	9,44592	10,55408	24
37	9,43007	9,98366	9,44641	10,55359	23
38	9,43053	9,98363	9,44690	10,55310	22
39	9,43098	9,98359	9,44738	10,55262	21
40	9,43143	9,98356	9,44787	10,55213	20
41	9,43188	9,98352	9,44836	10,55164	19
42	9,43233	9,98349	9,44884	10,55116	18
43	9,43278	9,98345	9,44933	10,55067	17
44	9,43323	9,98342	9,44981	10,55019	16
45	9,43367	9,98338	9,45029	10,54971	15
46	9,43412	9,98334	9,45078	10,54922	14
47	9,43457	9,98331	9,45126	10,54874	13
48	9,43502	9,98327	9,45174	10,54826	12
49	9,43546	9,98324	9,45222	10,54777	11
50	9,43591	9,98320	9,45271	10,54729	10
51	9,43635	9,98317	9,45319	10,54681	9
52	9,43680	9,98313	9,45367	10,54633	8
53	9,43724	9,98309	9,45415	10,54585	7
54	9,43769	9,98306	9,45463	10,54537	6
55	9,43813	9,98302	9,45511	10,54489	5
56	9,43857	9,98299	9,45559	10,54441	4
57	9,43901	9,98295	9,45606	10,54394	3
58	9,43946	9,98291	9,45654	10,54346	2
59	9,43990	9,98288	9,45702	10,54298	1
60	9,44034	9,98284	9,45750	10,54250	0
	Co-ſine	Sine	Co-tan.	Tangent	M

74 Degrees

16 Degrees

M	Sine	Co-ſine	Tangent	Co-tang	
0	9,44034	9,98284	9,45750	10,54250	60
1	9,44078	9,98280	9,45797	10,54203	59
2	9,44122	9,98277	9,45845	10,54155	58
3	9,44166	9,98273	9,45892	10,54107	57
4	9,44210	9,98270	9,45940	10,54060	56
5	9,44253	9,98266	9,45987	10,54012	55
6	9,44297	9,98262	9,46035	10,53965	54
7	9,44341	9,98259	9,46082	10,53918	53
8	9,44385	9,98255	9,46130	10,53870	52
9	9,44428	9,98251	9,46177	10,53823	51
10	9,44472	9,98248	9,46224	10,53776	50
11	9,44515	9,98244	9,46271	10,53728	49
12	9,44559	9,98240	9,46319	10,53681	48
13	9,44602	9,98237	9,46366	10,53634	47
14	9,44646	9,98233	9,46413	10,53587	46
15	9,44689	9,98229	9,46460	10,53540	45
16	9,44733	9,98226	9,46507	10,53493	44
17	9,44776	9,98222	9,46554	10,53446	43
18	9,44819	9,98218	9,46601	10,53399	42
19	9,44862	9,98215	9,46648	10,53352	41
20	9,44905	9,98211	9,46694	10,53305	40
21	9,44948	9,98207	9,46741	10,53259	39
22	9,44991	9,98203	9,46788	10,53212	38
23	9,45034	9,98200	9,46835	10,53165	37
24	9,45077	9,98196	9,46881	10,53119	36
25	9,45120	9,98192	9,46928	10,53072	35
26	9,45163	9,98189	9,46975	10,53025	34
27	9,45206	9,98185	9,47021	10,52979	33
28	9.45249	9,98181	9,47068	10,52932	32
29	9,45291	9,98177	9,47114	10,52886	31
30	9,45334	9,98174	9,47160	10,52839	30
31	9,45377	9,98170	9,47207	10,52793	29
32	9,45419	9,98166	9,47253	10,52747	28
33	9,45462	9,98162	9,47299	10,52700	27
34	9,45504	9,98159	9,47346	10,52654	26
35	9,45547	9,98155	9,47392	10,52608	25
36	9,45589	9,98151	9,47438	10,52562	24
37	9,45632	9,98148	9,47484	10,52516	23
38	9,45674	9,98144	9,47530	10,52470	22
39	9,45716	9,98140	9,47576	10,52424	21
40	9,45758	9,98136	9,47622	10,52378	20
41	9,45801	9,98132	9,47668	10,52332	19
42	9,45843	9,98128	9,47714	10,52286	18
43	9,45885	9,98125	9,47760	10,52240	17
44	9,45927	9,98121	9,47806	10,52194	16
45	9,45969	9,98117	9,47852	10,52148	15
46	9,46011	9,98113	9,47897	10,52102	14
47	9,46053	9,98109	9,47943	10,52057	13
48	9,46095	9,98106	9,47989	10,52011	12
49	9,46136	9,98102	9,48034	10,51965	11
50	9,46178	9,98098	9,48080	10,51920	10
51	9,46220	9,98094	9,48126	10,51874	9
52	9,46266	9,98090	9,48171	10,51829	8
53	9,46303	9,98087	9,48217	10,51783	7
54	9,46345	9,98083	9,48262	10,51738	6
55	9,46386	9,98079	9,48307	10,51692	5
56	9,46428	9,98075	9,48353	10,51647	4
57	9,46469	9,98071	9,48398	10,51602	3
58	9,46511	9,98067	9,48443	10,51556	2
59	9,46552	9,98063	9,48489	10,51511	1
60	9,46593	9,98060	9,48534	10,51466	0
	Co-ſine	Sine	Co-tan.	Tangent	M

73 Degrees

17 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,46593	9,98060	9,48534	10,51466	60
1	9,46635	9,98056	9,48579	10,51421	59
2	9,46676	9,98052	9,48624	10,51376	58
3	9,46717	9,98048	9,48669	10,51331	57
4	9,46758	9,98044	9,48714	10,51285	56
5	9,46800	9,98040	9,48759	10,51241	55
6	9,46841	9,98036	9,48804	10,51196	54
7	9,46882	9,98032	9,48849	10,51151	53
8	9,46923	9,98029	9,48894	10,51106	52
9	9,46964	9,98025	9,48939	10,51061	51
10	9,47004	9,98021	9,48984	10,51016	50
11	9,47045	9,98017	9,49029	10,50971	49
12	9,47086	9,98013	9,49073	10,50927	48
13	9,47127	9,98009	9,49118	10,50882	47
14	9,47168	9,98005	9,49163	10,50837	46
15	9,47209	9,98001	9,49207	10,50793	45
16	9,47249	9,97997	9,49252	10,50748	44
17	9,47290	9,97993	9,49296	10,50703	43
18	9,47330	9,97989	9,49341	10,50659	42
19	9,47371	9,97985	9,49385	10,50614	41
20	9,47411	9,97982	9,49430	10,50570	40
21	9,47452	9,97978	9,49474	10,50526	39
22	9,47492	9,97974	9,49519	10,50481	38
23	9,47533	9,97970	9,49563	10,50437	37
24	9,47573	9,97966	9,49607	10,50393	36
25	9,47613	9,97962	9,49651	10,50348	35
26	9,47654	9,97958	9,49696	10,50304	34
27	9,47694	9,97954	9,49740	10,50260	33
28	9,47734	9,97950	9,49784	10,50216	32
29	9,47774	9,97946	9,49828	10,50172	31
30	9,47814	9,97942	9,49872	10,50128	30
31	9,47854	9,97938	9,49916	10,50084	29
32	9,47894	9,97934	9,49960	10,50040	28
33	9,47934	9,97930	9,50004	10,49996	27
34	9,47974	9,97926	9,50048	10,49952	26
35	9,48014	9,97922	9,50092	10,49908	25
36	9,48054	9,97918	9,50136	10,49864	24
37	9,48094	9,97914	9,50180	10,49820	23
38	9,48133	9,97910	9,50223	10,49776	22
39	9,48173	9,97906	9,50267	10,49733	21
40	9,48213	9,97902	9,50311	10,49689	20
41	9,48252	9,97898	9,50355	10,49645	19
42	9,48292	9,97894	9,50398	10,49602	18
43	9,48332	9,97890	9,50442	10,49558	17
44	9,48371	9,97886	9,50485	10,49515	16
45	9,48411	9,97882	9,50529	10,49471	15
46	9,48450	9,97878	9,50572	10,49428	14
47	9,48489	9,97874	9,50616	10,49384	13
48	9,48529	9,97870	9,50659	10,49341	12
49	9,48568	9,97865	9,50703	10,49297	11
50	9,48607	9,97861	9,50746	10,49254	10
51	9,48647	9,97857	9,50789	10,49211	9
52	9,48686	9,97853	9,50833	10,49167	8
53	9,48725	9,97849	9,50876	10,49124	7
54	9,48764	9,97845	9,50919	10,49081	6
55	9,48803	9,97841	9,50962	10,49038	5
56	9,48842	9,97837	9,51005	10,48995	4
57	9,48881	9,97833	9,51048	10,48951	3
58	9,48920	9,97829	9,51092	10,48908	2
59	9,48959	9,97825	9,51135	10,48865	1
60	9,48998	9,97821	9,51178	10,48822	0
	Co-ſine	Sine	Co-tan.	Tangent	

72 Degrees

18 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,48998	9,97821	9,51178	10,48822	60
1	9,49037	9,97817	9,51221	10,48779	59
2	9,49076	9,97812	9,51263	10,48736	58
3	9,49115	9,97808	9,51306	10,48694	57
4	9,49153	9,97805	9,51349	10,48651	56
5	9,49192	9,97800	9,51392	10,48608	55
6	9,49231	9,97796	9,51435	10,48565	54
7	9,49269	9,97792	9,51478	10,48522	53
8	9,49308	9,97788	9,51520	10,48480	52
9	9,49347	9,97783	9,51563	10,48437	51
10	9,49385	9,97779	9,51606	10,48394	50
11	9,49424	9,97775	9,51648	10,48352	49
12	9,49462	9,97771	9,51691	10,48309	48
13	9,49500	9,97767	9,51733	10,48266	47
14	9,49539	9,97763	9,51776	10,48224	46
15	9,49577	9,97759	9,51818	10,48181	45
16	9,49615	9,97754	9,51861	10,48139	44
17	9,49654	9,97750	9,51903	10,48097	43
18	9,49692	9,97746	9,51946	10,48054	42
19	9,49730	9,97742	9,51988	10,48012	41
20	9,49768	9,97738	9,52030	10,47969	40
21	9,49806	9,97733	9,52073	10,47927	39
22	9,49844	9,97729	9,52115	10,47885	38
23	9,49882	9,97725	9,52157	10,47843	37
24	9,49920	9,97721	9,52199	10,47800	36
25	9,49958	9,97717	9,52242	10,47758	35
26	9,49996	9,97712	9,52284	10,47716	34
27	9,50034	9,97708	9,52326	10,47674	33
28	9,50073	9,97704	9,52368	10,47632	32
29	9,50110	9,97700	9,52410	10,47590	31
30	9,50148	9,97696	9,52452	10,47548	30
31	9,50185	9,97691	9,52494	10,47506	29
32	9,50223	9,97687	9,52536	10,47464	28
33	9,50261	9,97683	9,52578	10,47422	27
34	9,50298	9,97679	9,52620	10,47380	26
35	9,50336	9,97674	9,52661	10,47338	25
36	9,50373	9,97670	9,52703	10,47297	24
37	9,50411	9,97666	9,52745	10,47255	23
38	9,50448	9,97662	9,52787	10,47213	22
39	9,50486	9,97657	9,52828	10,47171	21
40	9,50523	9,97653	9,52870	10,47130	20
41	9,50561	9,97649	9,52912	10,47088	19
42	9,50598	9,97645	9,52953	10,47046	18
43	9,50635	9,97640	9,52995	10,47005	17
44	9,50673	9,97636	9,53037	10,46963	16
45	9,50710	9,97632	9,53078	10,46922	15
46	9,50747	9,97627	9,53120	10,46880	14
47	9,50784	9,97623	9,53161	10,46839	13
48	9,50821	9,97619	9,53202	10,46797	12
49	9,50858	9,97615	9,53244	10,46756	11
50	9,50896	9,97610	9,53285	10,46715	10
51	9,50933	9,97606	9,53327	10,46673	9
52	9,50970	9,97602	9,53368	10,46632	8
53	9,51006	9,97597	9,53409	10,46591	7
54	9,51043	9,97593	9,53450	10,46550	6
55	9,51080	9,97589	9,53492	10,46508	5
56	9,51117	9,97584	9,53533	10,46467	4
57	9,51154	9,97580	9,53574	10,46426	3
58	9,51191	9,97576	9,53615	10,46385	2
59	9,51227	9,97571	9,53656	10,46344	1
60	9,51264	9,97567	9,53698	10,46303	0
	Co-ſine	Sine	Co-tan.	Tangent	

71 Degrees

19 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,51264	9,97567	9,53697	10,46303	60
1	9,51301	9,97563	9,53738	10,46262	59
2	9,51337	9,97558	9,53779	10,46221	58
3	9,51374	9,97554	9,53820	10,46180	57
4	9,51411	9,97550	9,53861	10,46139	56
5	9,51447	9,97545	9,53902	10,46098	55
6	9,51484	9,97541	9,53943	10,46057	54
7	9,51520	9,97536	9,53984	10,46016	53
8	9,51557	9,97532	9,54024	10,45975	52
9	9,51593	9,97528	9,54065	10,45935	51
10	9,51629	9,97523	9,54106	10,45894	50
11	9,51666	9,97519	9,54147	10,45853	49
12	9,51702	9,97514	9,54187	10,45812	48
13	9,51738	9,97510	9,54228	10,45772	47
14	9,51774	9,97506	9,54269	10,45731	46
15	9,51811	9,97501	9,54309	10,45691	45
16	9,51847	9,97497	9,54350	10,45650	44
17	9,51883	9,97492	9,54390	10,45609	43
18	9,51919	9,97488	9,54431	10,45569	42
19	9,51955	9,97484	9,54471	10,45528	41
20	9,51991	9,97479	9,54512	10,45488	40
21	9,52027	9,97475	9,54552	10,45448	39
22	9,52063	9,97470	9,54593	10,45407	38
23	9,52099	9,97466	9,54633	10,45367	37
24	9,52135	9,97461	9,54673	10,45326	36
25	9,52171	9,97457	9,54714	10,45286	35
26	9,52207	9,97452	9,54754	10,45246	34
27	9,52242	9,97448	9,54794	10,45206	33
28	9,52278	9,97444	9,54834	10,45165	32
29	9,52314	9,97439	9,54875	10,45125	31
30	9,52349	9,97435	9,54915	10,45085	30
31	9,52385	9,97430	9,54955	10,45045	29
32	9,52421	9,97426	9,54995	10,45005	28
33	9,52456	9,97421	9,55035	10,44965	27
34	9,52492	9,97417	9,55075	10,44925	26
35	9,52527	9,97412	9,55115	10,44885	25
36	9,52563	9,97408	9,55155	10,44845	24
37	9,52598	9,97403	9,55195	10,44805	23
38	9,52634	9,97399	9,55235	10,44765	22
39	9,52669	9,97394	9,55275	10,44725	21
40	9,52705	9,97390	9,55315	10,44685	20
41	9,52740	9,97385	9,55355	10,44645	19
42	9,52775	9,97381	9,55395	10,44605	18
43	9,52810	9,97376	9,55434	10,44566	17
44	9,52846	9,97372	9,55474	10,44526	16
45	9,52881	9,97367	9,55514	10,44486	15
46	9,52916	9,97362	9,55554	10,44446	14
47	9,52951	9,97358	9,55593	10,44407	13
48	9,52986	9,97353	9,55633	10,44367	12
49	9,53021	9,97349	9,55673	10,44327	11
50	9,53056	9,97344	9,55712	10,44288	10
51	9,53091	9,97340	9,55752	10,44248	9
52	9,53126	9,97335	9,55791	10,44209	8
53	9,53161	9,97331	9,55831	10,44169	7
54	9,53196	9,97326	9,55870	10,44130	6
55	9,53231	9,97321	9,55910	10,44090	5
56	9,53266	9,97317	9,55949	10,44051	4
57	9,53301	9,97312	9,55988	10,44011	3
58	9,53336	9,97308	9,56028	10,43972	2
59	9,53370	9,97303	9,56067	10,43933	1
60	9,53405	9,97399	9,56107	10,43893	0
	Co-ſine	Sine	Co-tan.	Tangent	M

70 Degrees

20 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,53405	9,97299	9,56107	10,43893	60
1	9,53440	9,97294	9,56146	10,43854	59
2	9,53474	9,97289	9,56185	10,43815	58
3	9,53509	9,97285	9,56224	10,43776	57
4	9,53544	9,97280	9,56264	10,43736	56
5	9,53578	9,97275	9,56303	10,43697	55
6	9,53613	9,97271	9,56342	10,43658	54
7	9,53647	9,97266	9,56381	10,43619	53
8	9,53682	9,97262	9,56420	10,43580	52
9	9,53716	9,97257	9,56459	10,43541	51
10	9,53751	9,97252	9,56498	10,43502	50
11	9,53785	9,97248	9,56537	10,43463	49
12	9,53819	9,97243	9,56576	10,43424	48
13	9,53854	9,97238	9,56615	10,43385	47
14	9,53888	9,97234	9,56654	10,43346	46
15	9,53922	9,97229	9,56693	10,43307	45
16	9,53956	9,97224	9,56732	10,43268	44
17	9,53991	9,97220	9,56771	10,43229	43
18	9,54025	9,97215	9,56810	10,43190	42
19	9,54059	9,97210	9,56849	10,43151	41
20	9,54093	9,97206	9,56887	10,43113	40
21	9,54127	9,97201	9,56926	10,43074	39
22	9,54161	9,97196	9,56965	10,43035	38
23	9,54195	9,97192	9,57003	10,42996	37
24	9,54229	9,97187	9,57042	10,42958	36
25	9,54263	9,97182	9,57081	10,42919	35
26	9,54297	9,97178	9,57119	10,42880	34
27	9,54331	9,97173	9,57158	10,42842	33
28	9,54365	9,97168	9,57197	10,42803	32
29	9,54399	9,97163	9,57235	10,42765	31
30	9,54432	9,97159	9,57274	10,42726	30
31	9,54466	9,97154	9,57312	10,42688	29
32	9,54500	9,97149	9,57351	10,42649	28
33	9,54534	9,97145	9,57389	10,42611	27
34	9,54567	9,97140	9,57428	10,42572	26
35	9,54601	9,97135	9,57466	10,42534	25
36	9,54635	9,97130	9,57504	10,42496	24
37	9,54668	9,97126	9,57543	10,42457	23
38	9,54702	9,97121	9,57581	10,42419	22
39	9,54735	9,97116	9,57619	10,42381	21
40	9,54769	9,97111	9,57658	10,42342	20
41	9,54802	9,97106	9,57696	10,42304	19
42	9,54836	8,97102	9,57734	10,42266	18
43	9,54869	9,97097	9,57772	10,42228	17
44	9,54903	9,97092	9,57810	10,42190	16
45	9,54936	9,97087	9,57849	10,42151	15
46	9,54969	9,97083	9,57887	10,42113	14
47	9,55003	9,97078	9,57925	10,42075	13
48	9,55036	9,97073	9,57963	10,42037	12
49	9,55069	9,97068	9,58001	10,41999	11
50	9,55102	9,97063	9,58039	10,41961	10
51	9,55136	9,97059	9,58077	10,41923	9
52	9,55169	9,97054	9,58115	10,41885	8
53	9,55202	9,97049	9,58153	10,41847	7
54	9,55235	9,97044	9,58191	10,41809	6
55	9,55268	9,97039	9,58229	10,41771	5
56	9,55301	9,97034	9,58266	10,41733	4
57	9,55334	9,97030	9,58304	10,41696	3
58	9,55367	9,97025	9,58342	10,41658	2
59	9,55400	9,97020	9,58380	10,41620	1
60	9,55433	9,97015	9,58418	10,41582	0
	Co-ſine	Sine	Co-tan.	Tangent	M

69 Degrees

21 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,55433	9,97015	9,58418	10,41582	60
1	9,55466	9,97010	9,58455	10,41544	59
2	9,55499	9,97005	9,58493	10,41507	58
3	9,55531	9,97001	9,58531	10,41469	57
4	9,55564	9,96996	9,58569	10,41431	56
5	9,55597	9,96991	9,58606	10,41394	55
6	9,55630	9,96986	9,58644	10,41356	54
7	9,55663	9,96981	9,58681	10,41318	53
8	9,55695	9,96976	9,58719	10,41281	52
9	9,55728	9,96971	9,58757	10,41243	51
10	9,55761	9,96966	9,58794	10,41206	50
11	9,55793	9,96962	9,58832	10,41168	49
12	9,55826	9,96957	9,58869	10,41131	48
13	9,55858	9,96952	9,58907	10,41093	47
14	9,55891	9,96947	9,58944	10,41056	46
15	9,55923	9,96942	9,58981	10,41019	45
16	9,55956	9,96937	9,59019	10,40981	44
17	9,55988	9,96932	9,59056	10,40944	43
18	9,56021	9,96927	9,59093	10,40906	42
19	9,56053	9,96922	9,59131	10,40869	41
20	9,56085	9,96917	9,59168	10,40832	40
21	9,56118	9,96912	9,59205	10,40795	39
22	9,56150	9,96907	9,59243	10,40757	38
23	9,56182	9,96902	9,59280	10,40720	37
24	9,56215	9,96898	9,59317	10,40683	36
25	9,56247	9,96893	9,59354	10,40646	35
26	9,56279	9,96888	9,59391	10,40609	34
27	9,56311	9,96883	9,59428	10,40571	33
28	9,56343	9,96878	9,59466	10,40534	32
29	9,56375	9,96873	9,59503	10,40497	31
30	9,56407	9,96868	9,59540	10,40460	30
31	9,56440	9,96863	9,59577	10,40423	29
32	9,56472	9,96858	9,59614	10,40386	28
33	9,56504	9,96853	9,59651	10,40349	27
34	9,56536	9,96848	9,59688	10,40312	26
35	9,56568	9,96843	9,59725	10,40275	25
36	9,56599	9,96838	9,59762	10,40238	24
37	9,56631	9,96833	9,59798	10,40201	23
38	9,56663	9,96828	9,59835	10,40165	22
39	9,56695	9,96823	9,59872	10,40128	21
40	9,56727	9,96818	9,59909	10,40091	20
41	9,56759	9,96813	9,59946	10,40054	19
42	9,56790	9,96808	9,59983	10,40017	18
43	9,56822	9,96803	9,60019	10,39981	17
44	9,56854	9,96798	9,60056	10,39944	16
45	9,56885	9,96793	9,60093	10,39907	15
46	9,56917	9,96788	9,60130	10,39870	14
47	9,56949	9,96783	9,60166	10,39834	13
48	9,56980	9,96777	9,60203	10,39797	12
49	9,57012	9,96772	9,60239	10,39760	11
50	9,57043	9,96767	9,60276	10,39724	10
51	9,57075	9,96762	9,60313	10,39687	9
52	9,57107	9,96757	9,60349	10,39651	8
53	9,57138	9,96752	9,60386	10,39614	7
54	9,57169	9,96747	9,60422	10,39578	6
55	9,57201	9,96742	9,60459	10,39541	5
56	9,57232	9,96737	9,60495	10,39505	4
57	9,57264	9,96732	9,60532	10,39468	3
58	9,57295	9,96727	9,60568	10,39432	2
59	9,57326	9,96722	9,60605	10,39395	1
60	9,57357	9,96717	9,60641	10,39359	0
	Co-ſine	Sine	Co-tan.	Tangent	M

68 Degrees

22 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,57357	9,96717	9,60641	10,39359	60
1	9,57389	9,96711	9,60677	10,39323	59
2	9,57420	9,96706	9,60714	10,39286	58
3	9,57451	9,96701	9,60750	10,39250	57
4	9,57482	9,96696	9,60786	10,39214	56
5	9,57514	9,96691	9,60822	10,39177	55
6	9,57545	9,96686	9,60859	10,39141	54
7	9,57576	9,96681	9,60895	10,39105	53
8	9,57607	9,96676	9,60931	10,39069	52
9	9,57638	9,96670	9,60967	10,39033	51
10	9,57669	9,96665	9,61004	10,38996	50
11	9,57700	9,96660	9,61040	10,38960	49
12	9,57731	9,96655	9,61076	10,38924	48
13	9,57762	9,96650	9,61112	10,38888	47
14	9,57793	9,96645	9,61148	10,38852	46
15	9,57824	9,96639	9,61184	10,38816	45
16	9,57854	9,96634	9,61220	10,38780	44
17	9,57885	9,96629	9,61256	10,38744	43
18	9,57916	9,96624	9,61292	10,38708	42
19	9,57947	9,96619	9,61328	10,38672	41
20	9,57978	9,96614	9,61364	10,38636	40
21	9,58008	9,96608	9,61400	10,38600	39
22	9,58039	9,96603	9,61436	10,38564	38
23	9,58070	9,96598	9,61472	10,38528	37
24	9,58100	9,96593	9,61508	10,38492	36
25	9,58131	9,96588	9,61543	10,38456	35
26	9,58162	9,96582	9,61579	10,38421	34
27	9,58192	9,96577	9,61615	10,38385	33
28	9,58223	9,96572	9,61651	10,38349	32
29	9,58253	9,96567	9,61687	10,38313	31
30	9,58284	9,96561	9,61722	10,38278	30
31	9,58314	9,96556	9,61758	10,38242	29
32	9,58345	9,96551	9,61794	10,38206	28
33	9,58375	9,96546	9,61829	10,38170	27
34	9,58406	9,96541	9,61865	10,38135	26
35	9,58436	9,96535	9,61901	10,38099	25
36	9,58466	9,96530	9,61936	10,38063	24
37	9,58497	9,96525	9,61972	10,38028	23
38	9,58527	9,96519	9,62008	10,37992	22
39	9,58557	9,96514	9,62043	10,37957	21
40	9,58588	9,96509	9,62079	10,37921	20
41	9,58618	9,96504	9,62114	10,37886	19
42	9,58648	9,96498	9,62150	10,37850	18
43	9,58678	9,96493	9,62185	10,37815	17
44	9,58708	9,96488	9,62221	10,37779	16
45	9,58739	9,96483	9,62256	10,37744	15
46	9,58769	9,96477	9,62291	10,37708	14
47	9,58799	9,96472	9,62327	10,37673	13
48	9,58829	9,96467	9,62362	10,37638	12
49	9,58859	9,96461	9,62398	10,37602	11
50	9,58889	9,96456	9,62433	10,37567	10
51	9,58919	9,96451	9,62468	10,37532	9
52	9,58949	9,96445	9,62504	10,37496	8
53	9,58979	9,96440	9,62539	10,37461	7
54	9,59009	9,96435	9,62574	10,37426	6
55	9,59039	9,96429	9,62609	10,37391	5
56	9,59069	9,96424	9,62644	10,37355	4
57	9,59098	9,96419	9,62680	10,37320	3
58	9,59128	9,96413	9,62715	10,37285	2
59	9,59158	9,96408	9,62750	10,37250	1
60	9,59188	9,96403	9,62785	10,37215	0
	Co-ſine	Sine	Co-tan.	Tangent	M

67 Degrees

23 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,59188	9,96403	9,62785	10,37215	60
1	9,59217	9,96397	9,62820	10,37180	59
2	9,59247	9,96392	9,62855	10,37145	58
3	9,59277	9,96386	9,62890	10,37109	57
4	9,59307	9,96381	9,62925	10,37074	56
5	9,59336	9,96376	9,62961	10,37039	55
6	9,59366	9,96370	9,62996	10,37004	54
7	9,59395	9,96365	9,63031	10,36969	53
8	9,59425	9,96360	9,63066	10,36934	52
9	9,59455	9,96354	9,63100	10,36899	51
10	9,59484	9,96349	9,63135	10,36864	50
11	9,59514	9,96343	9,63170	10,36830	49
12	9,59543	9,96338	9,63205	10,36795	48
13	9,59573	9,96332	9,63240	10,36760	47
14	9,59602	9,96327	9,63275	10,36725	46
15	9,59631	9,96322	9,63310	10,36690	45
16	9,59661	9,96316	9,63344	10,36655	44
17	9,59690	9,96311	9,63379	10,36620	43
18	9,59720	9,96305	9,63414	10,36586	42
19	9,59749	9,96300	9,63449	10,36551	41
20	9,59778	9,96294	9,63484	10,36516	40
21	9,59807	9,96289	9,63518	10,36481	39
22	9,59837	9,96284	9,63553	10,36447	38
23	9,59866	9,96278	9,63588	10,36412	37
24	9,59895	9,96273	9,63623	10,36377	36
25	9,59924	9,96267	9,63657	10,36343	35
26	9,59954	9,96262	9,63692	10,36308	34
27	9,59983	9,96256	9,63726	10,36273	33
28	9,60012	9,96251	9,63761	10,36239	32
29	9,60041	9,96245	9,63796	10,36204	31
30	9,60070	9,96240	9,63830	10,36170	30
31	9,60099	9,96234	9,63865	10,36135	29
32	9,60128	9,96229	9,63899	10,36101	28
33	9,60157	9,96223	9,63934	10,36066	27
34	9,60186	9,96218	9,63968	10,36032	26
35	9,60215	9,96212	9,64003	10,35997	25
36	9,60244	9,96207	9,64037	10,35963	24
37	9,60273	9,96201	9,64072	10,35928	23
38	9,60302	9,96196	9,64106	10,35894	22
39	9,60330	9,96190	9,64140	10,35860	21
40	9,60359	9,96185	9,64175	10,35825	20
41	9,60388	9,96179	9,64209	10,35791	19
42	9,60417	9,96173	9,64243	10,35757	18
43	9,60446	9,96168	9,64278	10,35722	17
44	9,60474	9,96162	9,64312	10,35688	16
45	9,60503	9,96157	9,64346	10,35654	15
46	9,60532	9,96151	9,64381	10,35619	14
47	9,60561	9,96146	9,64415	10,35585	13
48	9,60589	9,96140	9,64449	10,35551	12
49	9,60618	9,96135	9,64483	10,35517	11
50	9,60646	9,96129	9,64517	10,35483	10
51	9,60675	9,96123	9,64552	10,35448	9
52	9,60704	9,96118	9,64586	10,35414	8
53	9,60732	9,96112	9,64620	10,35380	7
54	9,60761	9,96107	9,64654	10,35346	6
55	9,60789	9,96101	9,64688	10,35312	5
56	9,60818	9,96095	9,64722	10,35278	4
57	9,60846	9,96090	9,64756	10,35244	3
58	9,60874	9,96084	9,64790	10,35210	2
59	9,60903	9,96079	9,64824	10,35176	1
60	9,60931	9,96073	9,64858	10,35142	0
	Co-ſine	Sine	Co-tan.	Tangent	M

66 Degrees

24 Degrees

M	Sine	Co-fine	Tangent	Co-tang.	
0	9,60931	9,96073	9,64858	10,35142	60
1	9,60960	9,96067	9,64892	10,35108	59
2	9,60988	9,96062	9,64926	10,35074	58
3	9,61016	9,96056	9,64960	10,35040	57
4	9,61045	9,96050	9,64994	10,35006	56
5	9,61073	9,96045	9,65028	10,34972	55
6	9,61101	9,96039	9,65062	10,34938	54
7	9,61129	9,96033	9,65096	10,34904	53
8	9,61158	9,96028	9,65130	10,34870	52
9	9,61186	9,96022	9,65164	10,34836	51
10	9,61214	9,96016	9,65197	10,34803	50
11	9,61242	9,96011	9,65231	10,34769	49
12	9,61270	9,96005	9,65265	10,34735	48
13	9,61298	9,95999	9,65299	10,34701	47
14	9,61326	9,95994	9,65333	10,34667	46
15	9,61354	9,95988	9,65366	10,34634	45
16	9,61382	9,95982	9,65400	10,34600	44
17	9,61410	9,95977	9,65434	10,34566	43
18	9,61438	9,95971	9,65467	10,34533	42
19	9,61466	9,95965	9,65501	10,34499	41
20	9,61494	9,95960	9,65535	10,34465	40
21	9,61522	9,95954	9,65568	10,34432	39
22	9,61550	9,95948	9,65602	10,34398	38
23	9,61578	9,95942	9,65636	10,34364	37
24	9,61606	9,95937	9,65669	10,34331	36
25	9,61634	9,95931	9,65703	10,34297	35
26	9,61662	9,95925	9,65736	10,34264	34
27	9,61689	9,95919	9,65770	10,34230	33
28	9,61717	9,95914	9,65803	10,34197	32
29	9,61745	9,95908	9,65837	10,34163	31
30	9,61773	9,95902	9,65870	10,34130	30
31	9,61800	9,95896	9,65904	10,34096	29
32	9,61828	9,95891	9,65937	10,34063	28
33	9,61856	9,95885	9,65971	10,34029	27
34	9,61883	9,95879	9,66004	10,33996	26
35	9,61911	9,95873	9,66038	10,33962	25
36	9,61939	9,95868	9,66071	10,33929	24
37	9,61966	9,95862	9,66104	10,33896	23
38	9,61994	9,95856	9,66138	10,33862	22
39	9,62021	9,95850	9,66171	10,33829	21
40	9,62049	9,95844	9,66204	10,33796	20
41	9,62076	9,95838	9,66238	10,33762	19
42	9,62104	9,95833	9,66271	10,33729	18
43	9,62131	9,95827	9,66304	10,33696	17
44	9,62159	9,95821	9,66337	10,33662	16
45	9,62186	9,95815	9,66371	10,33629	15
46	9,62213	9,95810	9,66404	10,33596	14
47	9,62241	9,95804	9,66437	10,33563	13
48	9,62268	9,95798	9,66470	10,33530	12
49	9,62296	9,95792	9,66503	10,33496	11
50	9,62323	9,95786	9,66537	10,33463	10
51	9,62350	9,95780	9,66570	10,33430	9
52	9,62377	9,95775	9,66603	10,33397	8
53	9,62405	9,95769	9,66636	10,33364	7
54	9,62432	9,95763	9,66669	10,33331	6
55	9,62459	9,95757	9,66702	10,33298	5
56	9,62486	9,95751	9,66735	10,33265	4
57	9,62513	9,95745	9,66768	10,33232	3
58	9,62541	9,95739	9,66801	10,33199	2
59	9,62568	9,95733	9,66834	10,33166	1
60	9,62595	9,95728	9,66867	10,33133	0
	Co fine	Sine	Co-tan.	Tangent	M

65 Degrees

25 Degrees

M	Sine	Co-fine	Tangent	Co-tang.	
0	9,62595	9,95728	9,66867	10,33133	60
1	9,62622	9,95722	9,66900	10,33100	59
2	9,62649	9,95716	9,66933	10,33067	58
3	9,62676	9,95710	9,66966	10,33034	57
4	9,62703	9,95704	9,66999	10,33001	56
5	9,62730	9,95698	9,67032	10,32968	55
6	9,62757	9,95692	9,67065	10,32935	54
7	9,62784	9,95686	9,67098	10,32902	53
8	9,62811	9,95680	9,67131	10,32869	52
9	9,62838	9,95674	9,67163	10,32836	51
10	9,62865	9,95668	9,67196	10,32804	50
11	9,62892	9,95662	9,67229	10,32771	49
12	9,62918	9,95657	9,67262	10,32738	48
13	9,62945	9,95651	9,67295	10,32705	47
14	9,62972	9,95645	9,67327	10,32672	46
15	9,62999	9,95639	9,67360	10,32640	45
16	9,63025	9,95633	9,67393	10,32607	44
17	9,63052	9,95627	9,67426	10,32574	43
18	9,63079	9,95621	9,67458	10,32542	42
19	9,63106	9,95615	9,67491	10,32509	41
20	9,63133	9,95609	9,67524	10,32476	40
21	9,63160	9,95603	9,67556	10,32444	39
22	9,63186	9,95597	9,67589	10,32411	38
23	9,63212	9,95591	9,67622	10,32378	37
24	9,63239	9,95585	9,67654	10,32346	36
25	9,63266	9,95579	9,67687	10,32313	35
26	9,63292	9,95573	9,67719	10,32281	34
27	9,63319	9,95567	9,67752	10,32248	33
28	9,63345	9,95561	9,67785	10,32215	32
29	9,63372	9,95555	9,67817	10,32183	31
30	9,63398	9,95549	9,67850	10,32150	30
31	9,63425	9,95543	9,67882	10,32118	29
32	9,63451	9,95537	9,67915	10,32085	28
33	9,63478	9,95531	9,67947	10,32053	27
34	9,63504	9,95525	9,67979	10,32020	26
35	9,63531	9,95519	9,68012	10,31988	25
36	9,63567	9,95513	9,68044	10,31956	24
37	9,63583	9,95506	9,68077	10,31923	23
38	9,63610	9,95500	9,68109	10,31891	22
39	9,63636	9,95494	9,68142	10,31858	21
40	9,63662	9,95488	9,68174	10,31826	20
41	9,63689	9,95482	9,68206	10,31794	19
42	9,63715	9,95476	9,68239	10,31761	18
43	9,63741	9,95470	9,68271	10,31729	17
44	9,63767	9,95464	9,68303	10,31697	16
45	9,63793	9,95458	9,68336	10,31664	15
46	9,63820	9,95452	9,68368	10,31632	14
47	9,63846	9,95446	9,68400	10,31600	13
48	9,63872	9,95440	9,68432	10,31568	12
49	9,63898	9,95433	9,68465	10,31535	11
50	9,63924	9,95427	9,68497	10,31503	10
51	9,63950	9,95421	9,68529	10,31471	9
52	9,63976	9,95415	9,68561	10,31439	8
53	9,64002	9,95409	9,68593	10,31407	7
54	9,64028	9,95403	9,68625	10,31374	6
55	9,64054	9,95397	9,68658	10,31342	5
56	9,64080	9,95391	9,68690	10,31310	4
57	9,64106	9,95384	9,68722	10,31278	3
58	9,64132	9,95378	9,68754	[illegible]	2
59	9,64158	9,95372	9,68786	[illegible]	1
60	9,64184	9,95366	9,68818	[illegible]	0
	Co-fine	Sine	Co-tan.	[illegible]	[illegible]

64 Degrees

26 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,64184	9,95366	9,68818	10,31182	60
1	9,64210	9,95360	9,68850	10,31150	59
2	9,64236	9,95354	9,68882	10,31118	58
3	9,64262	9,95347	9,68914	10,31086	57
4	9,64288	9,95341	9,68946	10,31054	56
5	9,64313	9,95335	9,68978	10,31022	55
6	9,64339	9,95329	9,69010	10,30990	54
7	9,64365	9,95323	9,69042	10,30957	53
8	9,64391	9,95317	9,69074	10,30926	52
9	9,64416	9,95310	9,69106	10,30894	51
10	9,64442	9,95304	9,69138	10,30862	50
11	9,64468	9,95298	9,69170	10,30830	49
12	9,64494	9,95292	9,69202	10,30798	48
13	9,64519	9,95285	9,69234	10,30766	47
14	9,64545	9,95279	9,69266	10,30734	46
15	9,64571	9,95273	9,69297	10,30702	45
16	9,64596	9,95267	9,69329	10,30671	44
17	9,64622	9,95261	9,69361	10,30639	43
18	9,64647	9,95254	9,69393	10,30607	42
19	9,64673	9,95248	9,69425	10,30575	41
20	9,64698	9,95242	9,69457	10,30543	40
21	9,64724	9,95236	9,69488	10,30512	39
22	9,64749	9,95229	9,69520	10,30480	38
23	9,64775	9,95223	9,69552	10,30448	37
24	9,64800	9,95217	9,69583	10,30416	36
25	9,64826	9,95210	9,69615	10,30385	35
26	9,64851	9,95204	9,69647	10,30353	34
27	9,64877	9,95198	9,69679	10,30321	33
28	9,64902	9,95192	9,69710	10,30290	32
29	9,64927	9,95185	9,69742	10,30258	31
30	9,64953	9,95179	9,69774	10,30226	30
31	9,64978	9,95173	9,69805	10,30195	29
32	9,65003	9,95166	9,69837	10,30163	28
33	9,65029	9,95160	9,69868	10,30131	27
34	9,65054	9,95154	9,69900	10,30100	26
35	9,65079	9,95148	9,69932	10,30068	25
36	9,65104	9,95141	9,69963	10,30037	24
37	9,65130	9,95135	9,69995	10,30005	23
38	9,65155	9,95129	9,70026	10,29974	22
39	9,65180	9,95122	9,70058	10,29942	21
40	9,65205	9,95116	9,70089	10,29911	20
41	9,65230	9,95110	9,70120	10,29879	19
42	9,65255	9,95103	9,70152	10,29848	18
43	9,65281	9,95097	9,70184	10,29816	17
44	9,65306	9,95090	9,70215	10,29785	16
45	9,65331	9,95084	9,70247	10,29753	15
46	9,65356	9,95078	9,70278	10,29722	14
47	9,65381	9,95071	9,70309	10,29690	13
48	9,65406	9,95065	9,70341	10,29659	12
49	9,65431	9,95059	9,70372	10,29628	11
50	9,65456	9,95052	9,70404	10,29596	10
51	9,65481	9,95046	9,70435	10,29565	9
52	9,65506	9,95039	9,70466	10,29534	8
53	9,65531	9,95033	9,70498	10,29502	7
54	9,65556	9,95027	9,70529	10,29471	6
55	9,65580	9,95020	9,70560	10,29440	5
56	9,65605	9,95014	9,70592	10,29408	4
57	9,65630	9,95007	9,70623	10,29377	3
58	9,65655	9,95001	9,70654	10,29346	2
59	9,65680	9,95994	9,70685	10,29315	1
60	9,65705	9,94988	9,70717	10,29283	0
	Co-ſine	Sine	Co-tan.	Tangent	M

63 Degrees

27 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,65705	9,94988	9,70717	10,29283	60
1	9,65729	9,94982	9,70748	10,29252	59
2	9,65754	9,94975	9,70779	10,29221	58
3	9,65779	9,94969	9,70810	10,29190	57
4	9,65804	9,94962	9,70841	10,29159	56
5	9,65828	9,94956	9,70873	10,29127	55
6	9,65853	9,94949	9,70904	10,29096	54
7	9,65878	9,94943	9,70935	10,29065	53
8	9,65902	9,94936	9,70966	10,29034	52
9	9,65927	9,94930	9,70997	10,29003	51
10	9,65952	9,94923	9,71028	10,28972	50
11	9,65974	9,94917	9,71059	10,28941	49
12	9,66001	9,94910	9,71090	10,28910	48
13	9,66025	9,94904	9,71121	10,28878	47
14	9,66050	9,94897	9,71152	10,28847	46
15	9,66075	9,94891	9,71184	10,28816	45
16	9,66099	9,94884	9,71215	10,28785	44
17	9,66124	9,94878	9,71246	10,28754	43
18	9,66148	9,94871	9,71277	10,28723	42
19	9,66173	9,94865	9,71308	10,28692	41
20	9,66197	9,94858	9,71339	10,28661	40
21	9,66221	9,94852	9,71370	10,28630	39
22	9,66246	9,94845	9,71400	10,28599	38
23	9,66270	9,94839	9,71431	10,28568	37
24	9,66295	9,94832	9,71462	10,28538	36
25	9,66319	9,94826	9,71493	10,28507	35
26	9,66343	9,94819	9,71524	10,28476	34
27	9,66368	9,94813	9,71555	10,28445	33
28	9,66392	9,94806	9,71586	10,28414	32
29	9,66416	9,94799	9,71617	10,28383	31
30	9,66441	9,94793	9,71648	10,28352	30
31	9,66465	9,94786	9,71678	10,28321	29
32	9,66489	9,94780	9,71709	10,28291	28
33	9,66513	9,94773	9,71740	10,28260	27
34	9,66537	9,94766	9,71771	10,28229	26
35	9,66562	9,94760	9,71802	10,28198	25
36	9,66586	9,94753	9,71832	10,28167	24
37	9,66610	9,94747	9,71863	10,28 37	23
38	9,66634	9,94740	9,71894	10,28106	22
39	9,66658	9 94733	9,71925	10,28075	21
40	9,66682	9,94727	9,71955	10,28044	20
41	9,66706	9,94720	9,71986	10,28014	19
42	9,66730	9,94714	9,72017	10,27983	18
43	9,66755	9,94707	9,72048	10,27952	17
44	9,66779	9,94700	9,72078	10,27922	16
45	9,66803	9,94694	9,72109	10,27891	15
46	9,66827	9,94687	9,72140	10,27860	14
47	9,66851	9,94680	9,72170	10,27830	13
48	9,66875	9,94674	9,72201	10,27799	12
49	9,66899	9,94667	9,72231	10,27768	11
50	9,66922	9,94660	9,72262	10,27738	10
51	9,66946	9,94654	9,72293	10,27707	9
52	9,66970	9,94647	9,72323	10,27677	8
53	9,66994	9,94640	9,72354	10,27646	7
54	9,67018	9,94634	9,72384	10,27616	6
55	9,67042	9,94627	9,72415	10,27585	5
56	9,67066	9,94620	9,72445	10,27555	4
57	9,67090	9,94614	9,72476	10,27524	3
58	9,67113	9,94607	9,72506	10,27493	2
59	9,67137	9,94600	9,72537	10,27463	1
60	9,67161	9,94593	9,72567	10,27433	0
	Co-ſine	Sine	Co-tan.	Tangent	M

62 Degrees

28 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,67161	9,94593	9,72567	10,27433	60
1	9,67185	9,94587	9,72598	10,27402	59
2	9,67208	9,94580	9,72628	10,27372	58
3	9,67232	9,94573	9,72659	10,27341	57
4	9,67256	9,94567	9,72689	10,27311	56
5	9,67279	9,94560	9,72720	10,27280	55
6	9,67303	9,94553	9,72750	10,27250	54
7	9,67327	9,94546	9,72780	10,27219	53
8	9,67350	9,94540	9,72811	10,27189	52
9	9,67374	9,94533	9,72841	10,27159	51
10	9,67398	9,94526	9,72872	10,27128	50
11	9,67421	9,94519	9,72902	10,27098	49
12	9,67445	9,94512	9,72932	10,27068	48
13	9,67468	9,94506	9,72963	10,27037	47
14	9,67492	9,94499	9,72993	10,27007	46
15	9,67515	9,94492	9,73023	10,26977	45
16	9,67539	9,94485	9,73053	10,26946	44
17	9,67562	9,94479	9,73084	10,26916	43
18	9,67586	9,94472	9,73114	10,26886	42
19	9,67609	9,94465	9,73144	10,26856	41
20	9,67633	9,94458	9,73175	10,26825	40
21	9,67656	9,94451	9,73205	10,26795	39
22	9,67680	9,94445	9,73235	10,26765	38
23	9,67703	9,94438	9,73265	10,26735	37
24	9,67726	9,94431	9,73295	10,26704	36
25	9,67750	9,94424	9,73326	10,26674	35
26	9,67773	9,94417	9,73356	10,26644	34
27	9,67796	9,94410	9,73386	10,26614	33
28	9,67820	9,94404	9,73416	10,26584	32
29	9,67843	9,94397	9,73446	10,26554	31
30	9,67866	9,94390	9,73476	10,26524	30
31	9,67889	9,94383	9,73507	10,26493	29
32	9,67913	9,94376	9,73537	10,26463	28
33	9,67936	9,94369	9,73567	10,26433	27
34	9,67959	9,94362	9,73597	10,26403	26
35	9,67982	9,94355	9,73627	10,26373	25
36	9,68006	9,94349	9,73657	10,26343	24
37	9,68023	9,94342	9,73687	10,26313	23
38	9,68052	9,94335	9,73717	10,26283	22
39	9,68075	9,94328	9,73747	10,26253	21
40	9,68098	9,94321	9,73777	10,26223	20
41	9,68121	9,94314	9,73807	10,26193	19
42	9,68144	9,94307	9,73837	10,26163	18
43	9,68167	9,94300	9,73867	10,26133	17
44	9,68190	9,94293	9,73897	10,26103	16
45	9,68213	9,94286	9,73927	10,26073	15
46	9,68236	9,94279	9,73957	10,26043	14
47	9,68259	9,94272	9,73987	10,26013	13
48	9,68282	9,94266	9,74017	10,25983	12
49	9,68305	9,94259	9,74047	10,25953	11
50	9,68328	9,94252	9,74077	10,25923	10
51	9,68351	9,94245	9,74107	10,25893	9
52	9,68374	9,94238	9,74136	10,25863	8
53	9,68397	9,94231	9,74166	10,25834	7
54	9,68420	9,94224	9,74196	10,25803	6
55	9,68443	9,94217	9,74226	10,25774	5
56	9,68466	9,94210	9,74256	10,25744	4
57	9,68489	9,94203	9,74286	10,25714	3
58	9,68511	9,94196	9,74316	10,25684	2
59	9,68534	9,94189	9,74345	10,25655	1
60	9,68557	9,94182	9,74375	10,25625	0
	Co ſine	Sine	Co-tan.	Tangent	M

61 Degrees

29 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,68557	9,94182	9,74375	10,25625	60
1	9,68580	9,94175	9,74405	10,25595	59
2	9,68603	9,94168	9,74435	10,25565	58
3	9,68625	9,94161	9,74464	10,25535	57
4	9,68648	9,94154	9,74494	10,25506	56
5	9,68671	9,94147	9,74524	10,25476	55
6	9,68694	9,94140	9,74554	10,25446	54
7	9,68716	9,94133	9,74583	10,25416	53
8	9,68739	9,94126	9,74613	10,25387	52
9	9,68762	9,94119	9,74643	10,25357	51
10	9,68784	9,94112	9,74673	10,25327	50
11	9,68807	9,94105	9,74702	10,25298	49
12	9,68829	9,94097	9,74732	10,25268	48
13	9,68852	9,94090	9,74762	10,25238	47
14	9,68875	9,94083	9,74791	10,25209	46
15	9,68897	9,94076	9,74821	10,25179	45
16	9,68920	9,94069	9,74850	10,25149	44
17	9,68942	9,94062	9,74880	10,25120	43
18	9,68965	9,94055	9,74910	10,25090	42
19	9,68987	9,94048	9,74939	10,25061	41
20	9,69010	9,94041	9,74969	10,25031	40
21	9,69032	9,94034	9,74996	10,25001	39
22	9,69055	9,94027	9,75028	10,24972	38
23	9,69077	9,94020	9,75058	10,24942	37
24	9,69100	9,94012	9,75087	10,24913	36
25	9,69122	9,94005	9,75117	10,24883	35
26	9,69144	9,93998	9,75146	10,24854	34
27	9,69167	9,93991	9,75176	10,24824	33
28	9,69189	9,93984	9,75205	10,24795	32
29	9,69211	9,93977	9,75235	10,24765	31
3	9,69234	9,93970	9,75264	10,24736	30
31	9,69256	9,93962	9,75294	10,24706	29
32	9,69278	9,93955	9,75323	10,24677	28
33	9,69301	9,93948	9,75353	10,24647	27
34	9,69323	9,93941	9,75382	10,24618	26
35	9,69345	9,93934	9,75411	10,24588	25
36	9,69368	9,93927	9,75441	10,24559	24
37	9,69390	9,93919	9,75470	10,24530	23
38	9,69412	9,93912	9,75500	10,24500	22
39	9,69434	9,93905	9,75529	10,24471	21
40	9,69456	9,93898	9,75558	10,24441	20
41	9,69479	9,93891	9,75588	10,24412	19
42	9,69501	9,93884	9,75617	10,24383	18
43	9,69523	9,93876	9,75646	10,24353	17
44	9,69545	9,93869	9,75676	10,24324	16
45	9,69567	9,93862	9,75705	10,24295	15
46	9,69589	9,93855	9,75734	10,24265	14
47	9,69611	9,93847	9,75764	10,24236	13
48	9,69633	9,93840	9,75793	10,24207	12
49	9,60655	9,93833	9,75822	10,24178	11
50	9,69677	9,93826	9,75852	10,24148	10
51	9,69699	9,93818	9,75881	10,24119	9
52	9,69721	9,93811	9,75910	10,24090	8
53	9,69743	9,93804	9,75939	10,24060	7
54	9,69765	9,93797	9,75969	10,24031	6
55	9,69787	9,93789	9,75998	10,24002	5
56	9,69809	9,93782	9,76027	10,23973	4
57	9,69831	9,93775	9,76056	10,23944	3
58	9,69853	9,93768	9,76086	10,23914	2
59	9,69875	9,93760	9,76115	10,23885	1
60	9,69897	9,93753	9,76144	10,23856	0
	Co-ſine	Sine	Co-tan.	Tangent	M

60 Degrees

30 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,69897	9,93753	9,76144	10,23856	60
1	9,69919	9,93746	9,76173	10,23827	59
2	9,69941	9,93738	9,76202	10,23798	58
3	9,69963	9,93731	9,76231	10,23769	57
4	9,69984	9,93724	9,76261	10,23739	56
5	9,70006	9,93716	9,76290	10,23710	55
6	9,70028	9,93709	9,76319	10,23681	54
7	9,70050	9,93702	9,76348	10,23652	53
8	9,70072	9,93695	9,76377	10,23623	52
9	9,70093	9,93687	9,76406	10,23594	51
10	9,70115	9,93680	9,76435	10,23565	50
11	9,70137	9,93672	9,76464	10,23536	49
12	9,70158	9,93665	9,76493	10,23507	48
13	9,70180	9,93658	9,76522	10,23478	47
14	9,70202	9,93650	9,76551	10,23449	46
15	9,70224	9,93643	9,76580	10,23419	45
16	9,70245	9,93636	9,76609	10,23390	44
17	9,70267	9,93628	9,76638	10,23301	43
18	9,70288	9,93621	9,76667	10,23332	42
19	9,70310	9,93614	9,76696	10,23303	41
20	9,70332	9,93606	9,76725	10,23274	40
21	9,70353	9,93599	9,76754	10,23245	39
22	9,70375	9,93591	9,76783	10,23217	38
23	9,70396	9,93584	9,76812	10,23188	37
24	9,70418	9,93577	9,76841	10,23159	36
25	9,70439	9,93569	9,76870	10,23130	35
26	9,70461	9,93562	9,76899	10,23101	34
27	9,70482	9,93554	9,76928	10,23072	33
28	9,70504	9,93547	9,76957	10,23043	32
29	9,70525	9,93539	9,76986	10,23014	31
30	9,70547	9,93532	9,77015	10 22985	30
31	9,70568	9,93525	9,77044	10,22956	29
32	9,70590	9,93517	9,77073	10,22927	28
33	9,70611	9,93510	9,77101	10,22898	27
34	9,70633	9,93502	9,77130	10,22870	26
35	9,70654	9,93495	9,77159	10,22841	25
36	9,70675	9,93487	9,77188	10,22812	24
37	9,70697	9,93480	9,77217	10,22783	23
38	9,70718	9,93472	9,77246	10,22754	22
39	9,70739	9,93465	9,77274	10,22725	21
40	9,70761	9,93457	9,77303	10,22697	20
41	9,70782	9,93450	9,77332	10,22668	19
42	9,70803	9,93442	9,77361	10,22639	18
43	9,70824	9,93435	9,77390	10,22610	17
44	9,70846	9,93427	9,77418	10,22582	16
45	9,70867	9,93420	9,77447	10,22553	15
46	9,70888	9,93412	9,77476	10,22524	14
47	9,70909	9,93405	9,77505	10,22495	13
48	9,70931	9,93397	9,77533	10,22467	12
49	9,70952	9,93390	9,77562	10,22438	11
50	9,70973	9,93382	9,77591	10,22409	10
51	9,70994	9,93375	9,77619	10,22380	9
52	9,71015	9,93367	9,77648	10,22352	8
53	9,71036	9,93360	9,77677	10,22323	7
54	9,71057	9,93352	9,77705	10,22294	6
55	9,71079	9,93344	9,77734	10,22266	5
56	9,71100	9,93337	9,77763	10,22237	4
57	9,71121	9,93329	9,77791	10,22208	3
58	9,71142	9,93322	9,77820	10,22180	2
59	9,71163	9,93314	9,77849	10,22151	1
60	9,71184	9,93307	9,77877	10,22123	0
	Co-ſine	Sine	Co-tan.	Tangent	M

59 Degrees

31 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,71184	9,93307	9,77877	10,22123	60
1	9 71205	9,93299	9,77906	10,22094	59
2	9,71226	9,93291	9,77935	10,22065	58
3	9,71247	9.93284	9.77963	10,22037	57
4	9,71268	9,93276	9,77992	10,22008	56
5	9,71289	9,93268	9,78020	10,21980	55
6	9,71310	9,93261	9,78049	10,21951	54
7	9,71331	9,93253	9,78077	10,21922	53
8	9,71352	9,93246	9,78106	10,21894	52
9	9,71373	9,93238	9,78135	10.21865	51
10	9,71393	9,93230	9,78163	10,21837	50
11	9,71414	9,93223	9,78192	10,21808	49
12	9,71435	9,93215	9,78220	10,21780	48
13	9,71456	9,93207	9,78249	10,21751	47
14	9,71477	9,93200	9,78277	10,21723	46
15	9,71498	9,93192	9,78306	10,21694	45
16	9,71519	9,93184	9,78334	10,21666	44
17	9,71539	9,93177	9,78363	10,21637	43
18	9,71560	9,93169	9,78391	10,21609	42
19	9,71581	9,93161	9,78419	10,21580	41
20	9,71602	9,93154	9,78448	10,21552	40
21	9,71622	9,93146	9,78479	10,21524	39
22	9,71643	9,93138	9,78505	10,21495	38
23	9,71663	9,93131	9,78533	10,21467	37
24	9,71685	9,93123	9,78562	10,21438	36
25	9,71705	9,93115	9,78590	10,21410	35
26	9,71726	9,93107	9,78618	10,21382	34
27	9,71747	9,93100	9,78647	10,21353	33
28	9,71767	9,93092	9,78675	10,21325	32
29	9,71788	9,93084	9.78704	10,21296	31
30	9,71808	9,93077	9,78732	10,21268	30
31	9,71829	9,93069	9,78760	10,21240	29
32	9,71850	9,93061	9,78789	10,21211	28
33	9,71870	9,93053	9,78817	10,21183	27
34	9,71891	9,93046	9,78845	10,21155	26
35	9,71911	9,93038	9,78874	10,21126	25
36	9,71932	9,93030	9,78902	10,21098	24
37	9,71952	9,93022	9,78930	10,21070	23
38	9,71973	9,93014	9,78958	10,21041	22
39	9,71993	9,93007	9,78987	10,21013	21
40	9,72014	9,92999	9,79015	10,20985	20
41	9,72034	9,92991	9,79043	10,20957	19
42	9,72055	9,92983	9,79072	10,20928	18
43	9,72075	9,92975	9,79100	10,20900	17
44	9,72096	9,92968	9,79128	10,20872	16
45	9,72116	9,92960	9,79156	10,20844	15
46	9,72137	9,92952	9,79185	10,20815	14
47	9,72157	9,92944	9,79213	10,20787	13
48	9,72177	9,92936	9,79241	10,20759	12
49	9,72198	9,92929	9,79269	10,20731	11
50	9,72218	9,92921	9,79297	10,20703	10
51	9,72238	9,92913	9,79326	10,20674	9
52	9,72259	9,92905	9,79354	10,20646	8
53	9,72279	9,92897	9,79382	10,20618	7
54	9,72299	9,92889	9,79410	10,20590	6
55	9,72320	9,92881	9,79438	10,20562	5
56	9,72340	9,92874	9,79466	10,20534	4
57	9,72360	9,92866	9,79494	10,20505	3
58	9,72380	9,92858	9,79523	10,20477	2
59	9,72401	9,92850	9,79551	10,20449	1
60	9,72421	9,92842	9,79579	10,20421	0
	Co-ſine	Sine	Co-tan.	Tangent	M

58 Degrees

32 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,72421	9,92842	9,79579	10,20421	60
1	9,72441	9,92834	9,79607	10,20393	59
2	9,72461	9,92826	9,79635	10,20365	58
3	9,72482	9,92818	9,79663	10,20337	57
4	9,72502	9,92810	9,79691	10,20309	56
5	9,72522	9,92802	9,79719	10,20281	55
6	9,72542	9,92795	9,79747	10,20252	54
7	9,72562	9,92787	9,79775	10,20224	53
8	9,72582	9,92779	9,79804	10,20196	52
9	9,72602	9,92770	9,79832	10,20168	51
10	9,72622	9,92763	9,79860	10,20140	50
11	9,72643	9,92755	9,79888	10,20112	49
12	9,72663	9,92747	9,79916	10,20084	48
13	9,72683	9,92739	9,79944	10,20056	47
14	9,72703	9,92731	9,79972	10,20028	46
15	9,72723	9,92723	9,80000	10,20000	45
16	9,72743	9,92715	9,80028	10,19972	44
17	9,72763	9,92707	9,80056	10,19944	43
18	9,72783	9,92699	9,80084	10,19916	42
19	9,72803	9,92691	9,80112	10,19888	41
20	9,72823	9,92683	9,80140	10,19860	40
21	9,72843	9,92675	9,80167	10,19832	39
22	9,72863	9,92667	9,80195	10,19804	38
23	9,72882	9,92659	9,80223	10,19777	37
24	9,72902	9,92651	9,80251	10,19749	36
25	9,72922	9,92643	9,80279	10,19721	35
26	9,72942	9,92635	9,80307	10,19693	34
27	9,72962	9,92627	9,80335	10,19665	33
28	9,72982	9,92619	9,80363	10,19637	32
29	9,73002	9,92611	9,80391	10,19609	31
30	9,73022	9,92603	9,80419	10,19581	30
31	9,73041	9,92595	9,80447	10,19553	29
32	9,73061	9,92587	9,80474	10,19525	28
33	9,73081	9,92579	9,80502	10,19498	27
34	9,73101	9,92571	9,80530	10,19470	26
35	9,73121	9,92563	9,80558	10,19442	25
36	9,73140	9,92554	9,80586	10,19414	24
37	9,73160	9,92546	9,80614	10,19386	23
38	9,73180	9,92538	9,80641	10,19358	22
39	9,73200	9,92530	9,80669	10,19331	21
40	9,73219	9,92522	9,80697	10,19303	20
41	9,73239	9,92514	9,80725	10,19275	19
42	9,73259	9,92505	9,80753	10,19247	18
43	9,73278	9,92498	9,80780	10,19219	17
44	9,73298	9,92490	9,80808	10,19192	16
45	9,73318	9,92482	9,80836	10,19164	15
46	9,73337	9,92473	9,80864	10,19136	14
47	9,73357	9,92465	9,80892	10,19108	13
48	9,73376	9,92457	9,80919	10,19081	12
49	9,73396	9,92449	9,80947	10,19053	11
50	9,73416	9,92441	9,80975	10,19025	10
51	9,73435	9,92433	9,81002	10,18997	9
52	9,73455	9,92425	9,81030	10,18970	8
53	9,73474	9,92416	9,81058	10,18942	7
54	9,73494	9,92408	9,81086	10,18914	6
55	9,73513	9,92401	9,81113	10,18887	5
56	9,73533	9,92392	9,81141	10,18859	4
57	9,73552	9,92384	9,81169	10,18831	3
58	9,73572	9,92375	9,81196	10,18804	2
59	9,73591	9,92367	9,81224	10,18775	1
60	9,73611	9,92359	9,81252	10,18748	0
	Co ſine	Sine	Co-tan.	Tangent	M

57 Degrees

33 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,73611	9,92359	9,81252	10,18748	60
1	9,73630	9,92351	9,81279	10,18721	59
2	9,73650	9,92343	9,81307	10,18693	58
3	9,73669	9,92334	9,81335	10,18665	57
4	9,73689	9,92326	9,81362	10,18638	56
5	9,73708	9,92318	9,81390	10,18610	55
6	9,73727	9,92310	9,81417	10,18582	54
7	9,73747	9,92302	9,81445	10,18555	53
8	9,73766	9,92293	9,81473	10,18527	52
9	9,73785	9,92285	9,81500	10,18500	51
10	9,73805	9,92277	9,81528	10,18472	50
11	9,73824	9,92269	9,81555	10,18444	49
12	9,73843	9,92260	9,81583	10,18417	48
13	9,73863	9,92252	9,81611	10,18389	47
14	9,73882	9,92244	9,81638	10,18362	46
15	9,73901	9,92235	9,81666	10,18334	45
16	9,73920	9,92227	9,81693	10,18307	44
17	9,73940	9,92219	9,81721	10,18279	43
18	9,73959	9,92211	9,81748	10,18252	42
19	9,73978	9,92202	9,81776	10,18224	41
20	9,73997	9,92194	9,81803	10,18196	40
21	9,74017	9,92186	9,81831	10,18169	39
22	9,74036	9,92177	9,81858	10,18141	38
23	9,74057	9,92169	9,81886	10,18114	37
24	9,74074	9,92161	9,81913	10,18086	36
25	9,74093	9,92152	9,81941	10,18059	35
26	9,74112	9,92144	9,81968	10,18032	34
27	9,74132	9,92136	9,81996	10,18004	33
28	9,74151	9,92127	9,82023	10,17977	32
29	9,74170	9,92119	9,82051	10,17949	31
30	9,74189	9,92111	9,82078	10,17922	30
31	9,74208	9,92102	9,82106	10,17894	29
32	9,74227	9,92094	9,82133	10,17867	28
33	9,74246	9,92085	9,82161	10,17839	27
34	9,74265	9,92077	9,82188	10,17812	26
35	9,74284	9,92069	9,82215	10,17784	25
36	9,74303	9,92060	9,82243	10,17757	24
37	9,74322	9,92052	9,8227	10,17730	23
38	9,74341	9,92044	9,82298	10,17702	22
39	9,74360	9,92035	9,82325	10,17675	21
40	9,74379	9,92027	9,82352	10,17648	20
41	9,74398	9,92018	9,82380	10,17620	19
42	9,74417	9,92010	9,82407	10,17593	18
43	9,74436	9,92001	9,82434	10,17565	17
44	9,74455	9,91993	9,82462	10,17538	16
45	9,74474	9,91985	9,82489	10,17511	15
46	9,74493	9,91976	9,82517	10,17483	14
47	9,74512	9,91968	9,82544	10,17456	13
48	9,74531	9,91959	9,82571	10,17429	12
49	9,74549	9,91951	9,82599	10,17401	11
50	9,74568	9,91942	9,82626	10,17374	10
51	9,74587	9,91934	9,82653	10,17347	9
52	9,74606	9,91925	9,82680	10,17319	8
53	9,74625	9,91917	9,82708	10,17292	7
54	9,74644	9,91908	9,82735	10,17265	6
55	9,74662	9,91900	9,82762	10,17238	5
56	9,74681	9,91891	9,82790	10,17210	4
57	9,74700	9,91883	9,82817	10,17183	3
58	9,74719	9,91874	9,82844	10,17156	2
59	9,74737	9,91866	9,82871	10,17128	1
60	9,74756	9,91857	9,82899	10,17101	0
	Co-ſine	Sine	Co-tan.	Tangent	M

56 Degrees

34 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,74756	9,91857	9,82899	10,17101	60
1	9,74775	9,91849	9,82926	10,17074	59
2	9,74794	9,91840	9,82953	10,17047	58
3	9,74812	9,91832	9,82980	10,17019	57
4	9,74831	9,91823	9,83008	10,16992	56
5	9,74850	9,91815	9,83035	10,16965	55
6	9,74868	9,91806	9,83062	10,16938	54
7	9,74887	9,91798	9,83089	10,16911	53
8	9,74096	9,91789	9,83116	10,16883	52
9	9,74924	9,91780	9,83144	10,16856	51
10	9,74943	9,91772	9,83171	10,16829	50
11	9,74961	9,91763	9,83198	10,16802	49
12	9,74980	9,91755	9,83225	10,16775	48
13	9,74999	9,91746	9,83252	10,16747	47
14	9,75017	9,91738	9,83279	10,16720	46
15	9,75036	9,91729	9,83307	10,16693	45
16	9,75054	9,91720	9,83334	10,16666	44
17	9,75073	9,91712	9,83361	10,16639	43
18	9,75091	9,91703	9,83388	10,16612	42
19	9,75110	9,91694	9,83415	10,16585	41
20	9,75128	9,91686	9,83442	10,16557	40
21	9,75147	9,91677	9,83470	10,16530	39
22	9,75165	9,91668	9,83497	10,16503	38
23	9,75184	9,91660	9,83524	10,16476	37
24	9,75202	9,91651	9,83551	10,16449	36
25	9,75221	9,91643	9,83578	10,16422	35
26	9,75239	9,91634	9,83605	10,16395	34
27	9,75258	9,91625	9,83632	10,16368	33
28	9,75276	9,91617	9,83659	10,16341	32
29	9,75294	9,91608	9,83686	10,16314	31
30	9,75313	9,91599	9,83713	10,16287	30
31	9,75331	9,91591	9,83740	10,16259	29
32	9,75349	9,91582	9,83767	10,16232	28
33	9,75368	9,91573	9,83795	10,16205	27
34	9,75386	9,91565	9,83822	10,16178	26
35	9,75405	9,91556	9,83849	10,16151	25
36	9,75423	9,91547	9,83876	10,16124	24
37	9,75441	9,91538	9,83903	10,16097	23
38	9,75459	9,91530	9,83930	10,16070	22
39	9,75478	9,91521	9,83957	10,16043	21
40	9,75496	9,91512	9,83984	10,16016	20
41	9,75514	9,91503	9,84011	10,15989	19
42	9,75533	9,91495	9,84038	10,15962	18
43	9,75551	9,91486	9,84065	10,15935	17
44	9,75569	9,91477	9,84092	10,15908	16
45	9,75587	9,91468	9,84119	10,15881	15
46	9,75605	9,91460	9,84146	10,15854	14
47	9,75624	9,91451	9,84173	10,15827	13
48	9,75642	9,91442	9,84200	10,15800	12
49	9,75660	9,91433	9,84227	10,15773	11
50	9,75678	9,91425	9,84253	10,15746	10
51	9,75696	9,91416	9,84280	10,15719	9
52	9,75714	9,91407	9,84307	10,15693	8
53	9,75732	9,91398	9,84334	10,15666	7
54	9,75751	9,91389	9,84361	10,15639	6
55	9,75769	9,91381	9,84388	10,15612	5
56	9,75787	9,91372	9,84415	10,15585	4
57	9,75805	9,91363	9,84442	10,15558	3
58	9,75823	9,91354	9,84469	10,15531	2
59	9,75841	9,91345	9,84496	10,15504	1
60	9,75859	9,91336	9,84523	10,15477	0
	Co-ſine	Sine	Co-tan.	Tangent	M

55 Degrees

35 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,75859	9,91336	9,84523	10,15477	60
1	9,75877	9,91328	9,84550	10,15450	59
2	9,75895	9,91319	9,84576	10,15424	58
3	9,75913	9,91310	9,84603	10,15397	57
4	9,75931	9,91301	9,84630	10,15370	56
5	9,75949	9,91292	9,84657	10,15343	55
6	9,75967	9,91283	9,84684	10,15316	54
7	9,75985	9,91274	9,84711	10,15289	53
8	9,76003	9,91265	9,84738	10,15262	52
9	9,76021	9,91257	9,84764	10,15236	51
10	9,76039	9,91248	9,84791	10,15209	50
11	9,76057	9,91239	9,84818	10,15182	49
12	9,76075	9,91230	9,84845	10,15155	48
13	9,76093	9,91221	9,84872	10,15128	47
14	9,76111	9,91212	9,84898	10,15101	46
15	9,76128	9,91203	9,84925	10,15075	45
16	9,76146	9,91194	9,84952	10,15048	44
17	9,76164	9,91185	9,84979	10,15021	43
18	9,76182	9,91176	9,84006	10,14994	42
19	9,76200	9,91167	9,85032	10,14967	41
20	9,76218	9,91158	9,85059	10,14941	40
21	9,76236	9,91149	9,85086	10,14914	39
22	9,76253	9,91140	9,85113	10,14887	38
23	9,76271	9,91131	9,85140	10,14860	37
24	9,76289	9,91123	9,85166	10,14834	36
25	9,76307	9,91114	9,85193	10,14807	35
26	9,76324	9,91105	9,85220	10,14780	34
27	9,76342	9,91096	9,85247	10,14753	33
28	9,76360	9,91087	9,85273	10,14727	32
29	9,76378	9,91078	9,85300	10,14700	31
30	9,76395	9,91069	9,85327	10,14673	30
31	9,76413	9,91060	9,85353	10,14646	29
32	9,76431	9,91051	9,85380	10,14610	28
33	9,76448	9,91041	9,85407	10,14593	27
34	9,76466	9,91032	9,85434	10,14566	26
35	9,76484	9,91023	9,85460	10,14540	25
36	9,76501	9,91014	9,85487	10,14513	24
37	9,76519	9,91005	9,85514	10,14486	23
38	9,76537	9,90996	9,85540	10,14460	22
39	9,76554	9,90987	9,85567	10,14433	21
40	9,76572	9,90978	9,85594	10,14406	20
41	9,76590	9,90969	9,85620	10,14380	19
42	9,76607	9,90960	9,85647	10,14353	18
43	9,76625	9,90951	9,85674	10,14326	17
44	9,76642	9,90942	9,85700	10,14300	16
45	9,76660	9,90933	9,85727	10,14273	15
46	9,76677	9,90924	9,85754	10,14246	14
47	9,76695	9,90915	9,85780	10,14220	13
48	9,76712	9,90905	9,85807	10,14193	12
49	9,76729	9,90896	9,85834	10,14166	11
50	9,76747	9,90887	9,85860	10,14140	10
51	9,76765	9,90878	9,85887	10,14113	9
52	9,76782	9,90869	9,85913	10,14087	8
53	9,76800	9,90860	9,85940	10,14060	7
54	9,76817	9,90851	9,85967	10,14033	6
55	9,76835	9,90842	9,85993	10,14006	5
56	9,76852	9,90832	9,86020	10,13980	4
57	9,76870	9,90823	9,86046	10,13954	3
58	9,76887	9,90814	9,86073	10,13927	2
59	9,76904	9,90805	9,86099	10,13900	1
60	9,76922	9,90796	9,86126	10,13874	0
	Co-ſine	Sine	Co-tan.	Tangent	M

54 Degrees

36 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,76922	9,90796	9,86126	10,13874	60
1	9,76939	9,90787	9,86153	10,13847	59
2	9,76957	9,90777	9,86179	10,13821	58
3	9,76974	9,90768	9,86206	10,13794	57
4	9,76991	9,90759	9,86232	10,13768	56
5	9,77009	9,90750	9,86259	10,13741	55
6	9,77026	9,90741	9,86285	10,13715	54
7	9,77043	9,90731	9,86312	10,13688	53
8	9,77061	9,90722	9,86338	10,13661	52
9	9,77078	9,90713	9,86365	10,13635	51
10	9,77095	9,90704	9,86391	10,13608	50
11	9,77125	9,90694	9,86418	10,13582	49
12	9,77130	9,90685	9,86444	10,13555	48
13	9,77147	9,90676	9,86471	10,13529	47
14	9,77164	9,90667	9,86497	10,13502	46
15	9,77181	9,90657	9,86524	10,13476	45
16	9,77199	9,90648	9,86550	10,13449	44
17	9,77216	9,90639	9,86577	10,13423	43
18	9,77233	9,90630	9,86603	10,13396	42
19	9,77250	9,90620	9,86630	10,13370	41
20	9,77267	9,90611	9,86656	10,13344	40
21	9,77285	9,90602	9,86683	10,13317	39
22	9,77302	9,90592	9,86709	10,13291	38
23	9,77319	9,90583	9,86736	10,13264	37
24	9,77336	9,90574	9,86762	10,13238	36
25	9,77353	9,90564	9,86789	10,13211	35
26	9,77370	9,90555	9,86815	10,13185	34
27	9,77387	9,90546	9,86842	10,13158	33
28	9,77405	9,90537	9,86868	10,13132	32
29	9,77422	9,90527	9,86894	10,13106	31
30	9,77439	9,90518	9,86921	10,13079	30
31	9,77456	9,90508	9,86947	10,13053	29
32	9,77473	9,90499	9,86974	10,13026	28
33	9,77490	9,90490	9,87000	10,13000	27
34	9,77507	9,90480	9,87026	10,12973	26
35	9,77524	9,90471	9,87053	10,12947	25
36	9,77541	9,90462	9,87079	10,12921	24
37	9,77558	9,90453	9,87106	10,12894	23
38	9,77575	9,90443	9,87132	10,12868	22
39	9,77592	9,90433	9,87158	10,12841	21
40	9,77609	9,90424	9,87185	10,12815	20
41	9,77626	9,90415	9,87211	10,12789	19
42	9,77643	9,90405	9,87238	10,12762	18
43	9,77660	9,90396	9,87264	10,12736	17
44	9,77677	9,90386	9,87290	10,12710	16
45	9,77694	9,90377	9,87317	10,12683	15
46	9,77711	9,90368	9,87343	10,12657	14
47	9,77727	9,90358	9,87369	10,12631	13
48	9,77744	9,90349	9,87396	10,12604	12
49	9,77761	9,90339	9,87422	10,12578	11
50	9,77778	9,90330	9,87448	10,12551	10
51	9,77795	9,90320	9,87475	10,12525	9
52	9,77812	9,90311	9,87501	10,12499	8
53	9,77829	9,90301	9,87527	10,12473	7
54	9,77845	9,90293	9,87554	10,12446	6
55	9,77862	9,90282	9,87580	10,12420	5
56	9,77879	9,90273	9,87606	10,12394	4
57	9,77896	9,90263	9,87633	10,12367	3
58	9,77913	9,90254	9,87659	10,12341	2
59	9,77929	9,90244	9,87685	10,12315	1
60	9,77946	9,90235	9,87711	10,12289	0
	Co-ſine	Sine	Co-tan.	Tangent	M

53 Degrees

37 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,77946	9,90235	9,87711	10,12289	60
1	9,77963	9,90225	9,87738	10,12262	59
2	9,77980	9,90216	9,87764	10,12236	58
3	9,77996	9,90206	9,87790	10,12210	57
4	9,78013	9,90197	9,87816	10,12183	56
5	9,78030	9,90187	9,87843	10,12157	55
6	9,78047	9,90178	9,87869	10,12131	54
7	9,78063	9,90168	9,87895	10,12105	53
8	9,78080	9,90158	9,87921	10,12078	52
9	9,78097	9,90149	9,87948	10,12052	51
10	9,78113	9,90139	9,87974	10,12026	50
11	9,78130	9,90130	9,88000	10,12000	49
12	9,78147	9,90120	9,88026	10,11973	48
13	9,78163	9,90111	9,88053	10,11947	47
14	9,78180	9,90101	9,88080	10,11921	46
15	9,78197	9,90091	9,88105	10,11895	45
16	9,78213	9,90082	9,88131	10,11869	44
17	9,78230	9,90072	9,88158	10,11842	43
18	9,78246	9,90063	9,88184	10,11816	42
19	9,78263	9,90053	9,88210	10,11790	41
20	9,78280	9,90043	9,88236	10,11764	40
21	9,78296	9,90034	9,88262	10,11737	39
22	9,78313	9,90024	9,88289	10,11711	38
23	9,78329	9,90014	9,88315	10,11685	37
24	9,78346	9,90005	9,88341	10,11659	36
25	9,78362	9,89995	9,88367	10,11633	35
26	9,78379	9,89985	9,88393	10,11607	34
27	9,78395	9,89976	9,88420	10,11580	33
28	9,78412	9,89966	9,88445	10,11554	32
29	9,78428	9,89956	9,88472	10,11528	31
30	9,78445	9,89947	9,88498	10,11502	30
31	9,78461	9,89937	9,88524	10,11476	29
32	9,78478	9,89927	9,88550	10,11450	28
33	9,78494	9,89918	9,88576	10,11423	27
34	9,78510	9,89908	9,88603	10,11397	26
35	9,78527	9,89898	9,88629	10,11371	25
36	9,78543	9,89888	9,88655	10,11345	24
37	9,78560	9,89879	9,88681	10,11319	23
38	9,78576	9,89869	9,88707	10,11293	22
39	9,78593	9,89858	9,88733	10,11267	21
40	9,78609	9,89849	9,88759	10,11241	20
41	9,78625	9,89840	9,88785	10,11214	19
42	9,78642	9,89830	9,88812	10,11188	18
43	9,78658	9,89820	9,88838	10,11162	17
44	9,78674	9,89810	9,88864	10,11136	16
45	9,78691	9,89801	9,88890	10,11110	15
46	9,78707	9,89791	9,88916	10,11084	14
47	9,78723	9,89781	9,88942	10,11058	13
48	9,78739	9,89771	9,88968	10,11032	12
49	9,78756	9,89761	9,88994	10,11006	11
50	9,78772	9,89752	9,89020	10,10980	10
51	9,78788	9,89742	9,89046	10,10953	9
52	9,78804	9,89732	9,89072	10,10927	8
53	9,78821	9,89722	9,89099	10,10901	7
54	9,78837	9,89712	9,89125	10,10875	6
55	9,78853	9,89702	9,89151	10,10849	5
56	9,78869	9,89693	9,89177	10,10823	4
57	9,78886	9,89683	9,89203	10,10797	3
58	9,78902	9,89673	9,89229	10,10771	2
59	9,78918	9,89663	9,89255	10,10745	1
60	9,78934	9,89653	9,89281	10,10719	0
	Co-ſine	Sine	Co-tan.	Tangent	M

52 Degrees

38 Degrees

M	Sine	Co ſine	Tangent	Co-tang.	
0	9,78934	9,89653	9,89281	10,10719	60
1	9,78950	9,89643	9,89307	10,10693	59
2	9,78966	9,89633	9,89333	10,10667	58
3	9,78983	9,89624	9,89359	10,10641	57
4	9,78999	9,89614	9,89385	10,10615	56
5	9,79015	9,89604	9,89411	10,10589	55
6	9,79031	9,89594	9,89437	10,10563	54
7	9,79047	9,89584	9,89463	10,10537	53
8	9,79063	9,89574	9,89489	10,10511	52
9	9,79079	9,89564	9,89515	10,10485	51
10	9,79095	9,89554	9,89541	10,10459	50
11	9,79111	9,89544	9,89567	10,10433	49
12	9,79127	9,89534	9,89593	10,10407	48
13	9,79144	9,89524	9,89619	10,10381	47
14	9,79160	9,89514	9,89645	10,10355	46
15	9,79176	9,89504	9,89671	10,10329	45
16	9,79192	9,89494	9,89697	10,10303	44
17	9,79208	9,89485	9,89723	10,10277	43
18	9,79224	9,89475	9,89749	10,10250	42
19	9,79240	9,89465	9,89775	10,10225	41
20	9,79256	9,89455	9,89801	10,10199	40
21	9,79272	9,89445	9,89827	10,10173	39
22	9,79288	9,89435	9,89853	10,10147	38
23	9,79303	9,89425	9,89879	10,10121	37
24	9,79319	9,89415	9,89905	10,10095	36
25	9,79335	9,89405	9,89931	10,10069	35
26	9,79351	9,89395	9,89957	10,10043	34
27	9,79367	9,89385	9,89983	10,10017	33
28	9,79383	9,89374	9,90009	10,09991	32
29	9,79399	9,89364	9,90035	10,09965	31
30	9,79415	9,89354	9,90060	10,09939	30
31	9,79431	9,89344	9,90086	10,09913	29
32	9,79447	9,89334	9,90112	10,09888	28
33	9,79463	9,89324	9,90138	10,09862	27
34	9,79478	9,89314	9,90164	10,09836	26
35	9,79494	9,89304	9,90190	10,09810	25
36	9,79510	9,89294	9,90216	10,09784	24
37	9,79526	9,89284	9,90242	10,09758	23
38	9,79542	9,89274	9,90268	10,09732	22
39	9,79557	9,89264	9,90294	10,09706	21
40	9,79573	9,89254	9,90320	10,09680	20
41	9,79589	9,89243	9,90345	10,09654	19
42	9,79605	9,89233	9,90371	10,09629	18
43	9,79621	9,89223	9,90397	10,09603	17
44	9,79636	9,89213	9,90423	10,09577	16
45	9,79652	9,89203	9,90449	10,09551	15
46	9,79668	9,89193	9,90475	10,09525	14
47	9,79684	9,89183	9,90501	10,09499	13
48	9,79699	9,89173	9,90527	10,09473	12
49	9,79715	9,89162	9,90553	10,09447	11
50	9,79731	9,89152	9,90578	10,09421	10
51	9,79746	9,89142	9,90604	10,09396	9
52	9,79762	9,89132	9,90630	10,09370	8
53	9,79778	9,89122	9,90656	10,09344	7
54	9,79793	9,89111	9,90682	10,09318	6
55	9,79809	9,89101	9,90708	10,09292	5
56	9,79825	9,89091	9,90734	10,09266	4
57	9,79840	9,89081	9,90759	10,09241	3
58	9,79856	9,89071	9,90785	10,09215	2
59	9,79872	9,89060	9,90811	10,09189	1
60	9,79887	9,89050	9,90837	10,09163	0
	Co-ſine.	Sine	Co-tan.	Tangent.	M

51 Degrees

39 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,79887	9,89050	9,90837	10,09163	60
1	9,79903	9,89040	9,90863	10,09137	59
2	9,79918	9,89030	9,90889	10,09111	58
3	9,79934	9,89019	9,90914	10,09086	57
4	9,79949	9,89009	9,90940	10,09060	56
5	9,79965	9,88999	9,90966	10,09034	55
6	9,79981	9,88989	9,90992	10,09008	54
7	9,79996	9,88978	9,91018	10,08982	53
8	9,80012	9,88968	9,91043	10,08956	52
9	9,80027	9,88958	9,91069	10,08931	51
10	9,80043	9,88948	9,91095	10,08905	50
11	9,80058	9,88937	9,91121	10,08879	49
12	9,80074	9,88927	9,91147	10,08853	48
13	9,80089	9,88916	9,91172	10,08827	47
14	9,80105	9,88906	9,91198	10,08802	46
15	9,80120	9,88896	9,91224	10,08776	45
16	9,80136	9,88885	9,91250	10,08750	44
17	9,80151	9,88875	9,91276	10,08724	43
18	9,80166	9,88865	9,91301	10,08699	42
19	9,80182	9,88854	9,91327	10,08673	41
20	9,80197	9,88844	9,91353	10,08647	40
21	9,80213	9,88834	9,91379	10,08621	39
22	9,80228	9,88823	9,91404	10,08596	38
23	9,80243	9,88813	9,91430	10,08570	37
24	9,80259	9,88803	9,91456	10,08544	36
25	9,80274	9,88792	9,91482	10,08518	35
26	9,80290	9,88782	9,91507	10,08492	34
27	9,80305	9,88771	9,91533	10,08467	33
28	9,80320	9,88761	9,91559	10,08441	32
29	9,80336	9,88751	9,91585	10,08415	31
30	9,80351	9,88740	9,91610	10,08389	30
31	9,80366	9,88730	9,91636	10,08364	29
32	9,80382	9,88720	9,91662	10,08338	28
33	9,80397	9,88709	9,91688	10,08312	27
34	9,80412	9,88699	9,91713	10,08287	26
35	9,80428	9,88688	9,91739	10,08261	25
36	9,80443	9,88678	9,91765	10,08235	24
37	9,80458	9,88668	9,91790	10,08209	23
38	9,80473	9,88657	9,91816	10,08184	22
39	9,80489	9,88647	9,91842	10,08158	21
40	9,80504	9,88636	9,91868	10,08132	20
41	9,80519	9,88626	9,91893	10,08107	19
42	9,80534	9,88615	9,91919	10,08081	18
43	9,80549	9,88605	9,91945	10,08055	17
44	9,80565	9,88594	9,91970	10,08029	16
45	9,80580	9,88584	9,91996	10,08004	15
46	9,80595	9,88573	9,92022	10,07978	14
47	9,80610	9,88563	9,92048	10,07952	13
48	9,80625	9,88552	9,92073	10,07927	12
49	9,80641	9,88542	9,92099	10,07901	11
50	9,80656	9,88531	9,92125	10,07875	10
51	9,80671	9,88520	9,92150	10,07850	9
52	9,80686	9,88510	9,92176	10,07824	8
53	9,80701	9,88499	9,92202	10,07798	7
54	9,80716	9,88489	9,92227	10,07773	6
55	9,80731	9,88478	9,92253	10,07747	5
56	9,80746	9,88468	9,92279	10,07721	4
57	9,80761	9,88457	9,92304	10,07696	3
58	9,80777	9,88447	9,92330	10,07670	2
59	9,80792	9,88436	9,92356	10,07644	1
60	9,80806	9,88425	9,92381	10,07619	0
	Co-ſine	Sine	Co-tan.	Tangent	M

50 Degrees

40 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,80807	9,88425	9,92381	10,07619	60
1	9,80822	9,88415	9,92407	10,07593	59
2	9,80837	9,88404	9,92433	10,07567	58
3	9,80852	9,88394	9,92458	10,07542	57
4	9,80867	9,88383	9,92484	10,07516	56
5	9,80882	9,88372	9,92510	10,07490	55
6	9,80897	9,88362	9,92535	10,07465	54
7	9,80912	9,88351	9,92561	10,07439	53
8	9,80927	9,88340	9,92586	10,07413	52
9	9,80942	9,88330	9,92612	10,07388	51
10	9,80957	9,88319	9,92638	10,07362	50
11	9,80972	9,88308	9,92663	10,07337	49
12	9,80987	9,88298	9,92689	10,07311	48
13	9,81002	9,88287	9,92715	10,07285	47
14	9,81017	9,88276	9,92740	10,07260	46
15	9,81032	9,88266	9,92766	10,07234	45
16	9,81046	9,88255	9,92791	10,07208	44
17	9,81061	9,88244	9,92817	10,07183	43
18	9,81076	9,88234	9,92843	10,07157	42
19	9,81091	9,88223	9,92868	10,07132	41
20	9,81106	9,88212	9,92894	10,07106	40
21	9,81121	9,88201	9,92920	10,07080	39
22	9,81136	9,88191	9,92945	10,07055	38
23	9,81151	9,88180	9,92971	10,07029	37
24	9,81165	9,88169	9,92996	10,07004	36
25	9,81180	9,88158	9,93022	10,06978	35
26	9,81195	9,88148	9,93047	10,06952	34
27	9,81210	9,88137	9,93073	10,06927	33
28	9,81225	9,88126	9,93099	10,06901	32
29	9,81240	9,88115	9,93124	10,06876	31
30	9,81254	9,88105	9,93150	10,06850	30
31	9,81269	9,88094	9,93175	10,06824	29
32	9,81284	9,88083	9,93201	10,06799	28
33	9,81299	9,88072	9,93227	10,06773	27
34	9,81313	9,88061	9,93252	10,06748	26
35	9,81328	9,88050	9,93278	10,06722	25
36	9,81343	9,88040	9,93303	10,06697	24
37	9,81358	9,88029	9,93329	10,06671	23
38	9,81372	9,88018	9,93354	10,06645	22
39	9,81387	9,88007	9,93380	10,06620	21
40	9,81402	9,87996	9,93406	10,06594	20
41	9,81417	9,87985	9,93431	10,06569	19
42	9,81431	9,87975	9,93457	10,06543	18
43	9,81446	9,87964	9,93482	10,06518	17
44	9,81461	9,87953	9,93508	10,06492	16
45	9,81475	9,87942	9,93533	10,06467	15
46	9,81490	9,87931	9,93559	10,06441	14
47	9,81505	9,87920	9,93584	10,06416	13
48	9,81519	9,87909	9,93610	10,06390	12
49	9,81534	9,87898	9,93635	10,06364	11
50	9,81548	9,87887	9,93661	10,06339	10
51	9,81563	9,87877	9,93687	10,06413	9
52	9,81578	9,87866	9,93712	10,06288	8
53	9,81592	9,87855	9,93738	10,06262	7
54	9,81607	9,87844	9,93763	10,06237	6
55	9,81621	9,87833	9,93789	10,06211	5
56	9,81636	9,87822	9,93814	10,06186	4
57	9.81651	9,87811	9,93840	10,06160	3
58	9,81665	9,87800	9,93865	10,06135	2
59	9,81680	9,87789	9,93891	10,06109	1
60	9,81694	9,87778	9,93916	10,06084	0
M	Co-ſine	Sine	Co-tan.	Tangent	M

49 Degrees

41 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,81694	9,87778	9,93916	10,06084	60
1	9,81709	9,87767	9,93942	10,06058	59
2	9,81723	9,87756	9,93967	10,06033	58
3	9,81738	9,87745	9,93993	10,06007	57
4	9,81752	9,87734	9,94018	10,05982	56
5	9,81767	9,87723	9,94044	10,05956	55
6	9,81781	9,87712	9,94069	10,05931	54
7	9,81796	9,87701	9,94095	10,05905	53
8	9,81810	9,87690	9,94120	10,05880	52
9	9,81825	9,87679	9,94146	10,05854	51
10	9,81839	9,87668	9,94171	10,05829	50
11	9,81854	9,87657	9,94197	10,05803	49
12	9,81868	9,87646	9,94222	10,05778	48
13	9,81882	9,87635	9,94248	10,05752	47
14	9,81897	9,87624	9,94273	10,05727	46
15	9,81911	9,87612	9,94299	10,05701	45
16	9,81926	9,87601	9,94324	10,05676	44
17	9,81940	9,87590	9,94350	10,05650	43
18	9,81954	9,87579	9,94375	10,05625	42
19	9,81969	9,87568	9,94401	10,05593	41
20	9,81983	9,87557	9,94426	10,05574	40
21	9,81998	9,87546	9,94452	10,05548	39
22	9,82012	9,87535	9,94477	10,05523	38
23	9,82026	9,87524	9,94503	10,05497	37
24	9,82041	9,87513	9,94528	10,05472	36
25	9,82055	9,87501	9,94553	10,05446	35
26	9.82069	9,87490	9,94579	10,05421	34
27	9,82084	9,87479	9,94604	10,05395	33
28	9,82098	9,87468	9,94630	10,05370	32
29	9,82112	9,87457	9,94655	10,05345	31
30	9,82126	9,87446	9,94681	10,05319	30
31	9,82140	9,87434	9,94706	10,05294	29
32	9,82155	9,87423	9,94732	10,05268	28
33	9,82169	9,87412	9,94757	10,05243	27
34	9,82183	9,87401	9,94783	10,05217	26
35	9,82198	9,87390	9,94808	10,05192	25
36	9,82212	9,87378	9,94833	10,05166	24
37	9,82226	9,87367	9,94859	10,05141	23
38	9,82240	9,87356	9,94884	10,05116	22
39	9,82255	9,87345	9,94910	10,05090	21
40	9,82269	9,87333	9,94925	10,05065	20
41	9,82283	9,87322	9,94961	10,05039	19
42	9,82297	9,87311	9,94986	10,05014	18
43	9,82311	9,87300	9,95012	10,04988	17
44	9,82325	9,87288	9,95037	10,04963	16
45	9,82340	9,87277	9,95062	10,04937	15
46	9,82353	9,87266	9,95088	10,04912	14
47	9,82368	9,87255	9,95113	10,04887	13
48	9,82382	9,87243	9,95139	10,04861	12
49	9,82396	9,87232	9,95164	10,04836	11
50	9,82410	9,87221	9,95190	10,04810	10
51	9,82424	9.87209	9,95215	10,04785	9
52	9,82439	9,87198	9,95240	10,04759	8
53	9,82453	9,87187	9,95266	10,04734	7
54	9,82467	9,87175	9,95291	10,04709	6
55	9,82481	9,87164	9,95317	10,04683	5
56	9,82495	9,87153	9,95342	10,04658	4
57	9,82509	9,87141	9,95367	10,04632	3
58	9,82523	9,87130	9,95393	10,04607	2
59	9,82537	9,87119	9,95418	10,04582	1
60	9,82551	9,87107	9,95444	10,04556	0
	Co-ſine	Sine	Co-tan.	Tangent	

48 Degrees

42 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,82551	9,87107	9,95444	10,04556	60
1	9,82565	9,87096	9,95469	10,04531	59
2	9,82579	9,87085	9,95494	10,04505	58
3	9,82593	9,87073	9,95520	10,04480	57
4	9,82607	9,87062	9,95545	10,04455	56
5	9,82621	9,87050	9,95571	10,04429	55
6	9,82635	9,87039	9,95596	10,04404	54
7	9,82649	9,87028	9,95621	10,04378	53
8	9,82663	9,87016	9,95647	10,04353	52
9	9,82677	9,87005	9,95672	10,04328	51
10	9,82691	9,86993	9,95698	10,04302	50
11	9,82705	9,86982	9,95723	10,04277	49
12	9,82719	9,86970	9,95748	10,04251	48
13	9,82733	9,86959	9,95774	10,04226	47
14	9,82747	9,86947	9,95799	10,04201	46
15	9,82761	9,86936	9,95825	10,04175	45
16	9,82774	9,86924	9,95850	10,04150	44
17	9,82788	9,86913	9,95875	10,04125	43
18	9,82802	9,86901	9,95901	10,04099	42
19	9,82816	9,86890	9,95926	10,04074	41
20	9,82830	9,86878	9,95951	10,04048	40
21	9,82844	9,86867	9,95977	10,04023	39
22	9,82858	9,86855	9,96002	10,03998	38
23	9,82872	9,86844	9,96028	10,03972	37
24	9,82885	9,86832	9,96053	10,03947	36
25	9,82899	9,86821	9,96078	10,03922	35
26	9,82913	9,86809	9,96104	10,03896	34
27	9,82927	9,86798	9,96129	10,03871	33
28	9,82941	9,86786	9,96154	10,03845	32
29	9,82954	9,86775	9,96180	10,03820	31
30	9,82968	9,86763	9,96205	10,03795	30
31	9,82982	9,86751	9,96231	10,03769	29
32	9,82996	9,86740	9,96256	10,03744	28
33	9,83010	9,86728	9,96281	10,03719	27
34	9,83023	9,86717	9,96307	10,03693	26
35	9,83037	9,86705	9,96332	10,03668	25
36	9,83051	9,86693	9,96357	10,03643	24
37	9,83065	9,86682	9,96383	10,03617	23
38	9,83078	9,86670	9,96408	10,03592	22
39	9,83092	9,86659	9,96433	10,03566	21
40	9,83106	9,86647	9,96459	10,03541	20
41	9,83119	9,86635	9,96484	10,03516	19
42	9,83133	9,86624	9,96509	10,03490	18
43	9,83147	9,86612	9,96535	10,03465	17
44	9,83161	9,86600	9,96560	10,03440	16
45	9,83174	9,86589	9,96585	10,03414	15
46	9,83188	9,86577	9,96611	10,03389	14
47	9,83201	9,86565	9,96636	10,03364	13
48	9,83215	9,86553	9,96662	10,03338	12
49	9,83229	9,86542	9,96687	10,03313	11
50	9,83242	9,86530	9,96712	10,03288	10
51	9,83256	9,86518	9,96738	10,03262	9
52	9,83270	9,86507	9,96763	10,03237	8
53	9,83283	9,86495	9,96788	10,03212	7
54	9,83297	9,86483	9,96814	10,03186	6
55	9,83310	9,86472	9,96839	10,03161	5
56	9,83324	9,86460	9,96864	10,03136	4
57	9,83338	9,86448	9,96890	10,03110	3
58	9,83351	9,86436	9,96915	10,03085	2
59	9,83365	9,86424	9,96940	10,03060	1
60	9,83378	9,86413	9,96966	10,03034	0
	Co ſine	Sine	Co-tan.	Tangent	M

47 Degress

43 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,83378	9,86413	9,96966	10,03034	60
1	9,83392	9,86401	9,96991	10,03009	59
2	9,83405	9,86389	9,97016	10,02984	58
3	9,83419	9,86377	9,97041	10,02958	57
4	9,83432	9,86366	9,97067	10,02933	56
5	9,83446	9,86354	9,97092	10,02908	55
6	9,83459	9,86342	9,97117	10,02882	54
7	9,83473	9,86330	9,97143	10,02857	53
8	9,83486	9,86318	9,97168	10,02832	52
9	9,83500	9,86306	9,97193	10,02806	51
10	9,83513	9,86295	9,97219	10,02781	50
11	9,83527	9,86283	9,97244	10,02756	49
12	9,83540	9,86271	9,97269	10,02730	48
13	9,83554	9,86259	9,97295	10,02705	47
14	9,83567	9,86247	9,97320	10,02680	46
15	9,83581	9,86235	9,97345	10,02655	45
16	9,83594	9,86223	9,97371	10,02629	44
17	9,83607	9,86211	9,97396	10,02604	43
18	9,83621	9,86200	9,97421	10,02579	42
19	9,83634	9,86188	9,97447	10,02553	41
20	9,83648	9,86176	9,97472	10,02528	40
21	9,83661	9,86164	9,97497	10,02503	39
22	9,83674	9,86152	9,97523	10,02477	38
23	9,83688	9,86140	9,97548	10,02452	37
24	9,83701	9,86128	9,97573	10,02427	36
25	9,83715	9,86116	9,97598	10,02401	35
26	9,83738	9,86104	9,97624	10,02376	34
27	9,83741	9,86092	9,97649	10,02351	33
28	9,83755	9,86080	9,97674	10,02326	32
29	9,83768	9,86068	9,97700	10,02300	31
30	9,83781	9,86056	9,97725	10,02275	30
31	9,83794	9,86044	9,97750	10,02250	29
32	9,83808	9,86032	9,97776	10,02224	28
33	9,83821	9,86020	9,97801	10,02199	27
34	9,83834	9,86008	9,97826	10,02174	26
35	9,83848	9,85996	9,97851	10,02148	25
36	9,83861	9,85984	9,97877	10,02123	24
37	9,83874	9,85972	9,97902	10,02098	23
38	9,83887	9,85960	9,97927	10,02073	22
39	9,83901	9,85948	9,97953	10,02047	21
40	9,83914	9,85936	9,97978	10,02022	20
41	9,83927	9,85924	9,98003	10,01997	19
42	9,83940	9,85912	9,98029	10,01971	18
43	9,83954	9,85900	9,98054	10,01946	17
44	9,83967	9,85888	9,98079	10,01921	16
45	9,83980	9,85876	9,98104	10,01896	15
46	9,83993	9,85863	9,98130	10,01870	14
47	9,84006	9,85851	9,98155	10,01845	13
48	9,84020	9,85839	9,98180	10,01820	12
49	9,84033	9,85827	9,98206	10,01794	11
50	9,84046	9,85815	9,98231	10,01769	10
51	9,84059	9,85803	9,98256	10,01744	9
52	9,84072	9,85791	9,98281	10,01718	8
53	9,84085	9,85779	9,98307	10,01693	7
54	9,84098	9,85766	9,98332	10,01668	6
55	9,84112	9,85754	9,98357	10,01643	5
56	9,84125	9,85742	9,98383	10,01617	4
57	9,84138	9,85730	9,98408	10,01592	3
58	9,84151	9,85718	9,98433	10,01567	2
59	9,84164	9,85706	9,98458	10,01542	1
60	9,84177	9,85693	9,98484	10,01516	0
	Co-ſine	Sine	Co-tan.	Tangent	M

46 Degrees

44 Degrees

M	Sine	Co-ſine	Tangent	Co-tang.	
0	9,84177	9,85693	9,98484	10,01516	60
1	9,84190	9,85681	9,98509	10,01491	59
2	9,84203	9,85669	9,98534	10,01466	58
3	9,84216	9,85657	9,98560	10,01440	57
4	9,84229	9,85644	9,98585	10,01415	56
5	9,84242	9,85632	9,98610	10,01390	55
6	9,84255	9,85620	9,98635	10,01365	54
7	9,84268	9,85608	9,98661	10,01339	53
8	9,84281	9,85596	9,98986	10,01314	52
9	9,84295	9,85583	9,98711	10,01289	51
10	9,84308	9,85571	9,98736	10,01263	50
11	9,84320	9,85559	9,98762	10,01238	49
12	9,84334	9,85546	9,98787	10,01213	48
13	9,84346	9,85534	9,98812	10,01188	47
14	9,84359	9,85522	9,98838	10,01162	46
15	9,84372	9,85510	9,98863	10,01137	45
16	9,84385	9,85497	9,98888	10,01112	44
17	9,84398	9,85485	9,98913	10,01087	43
18	9,84411	9,85473	9,98939	10,01061	42
19	9,84424	9,85460	9,98964	10,01036	41
20	9,84437	9,85448	9,98989	10,01011	40
21	9,84450	9,85436	9,99014	10,00985	39
22	9,84463	9,85423	9,99040	10,00960	38
23	9,84476	9,85411	9,99065	10,00935	37
24	9,84489	9,85398	9,99090	10,00909	36
25	9,84502	9,85386	9,99116	10,00884	35
26	9,84515	9,85374	9,99141	10,00859	34
27	9,84528	9,85361	9,99166	10,00834	33
28	9,84540	9,85349	9,99191	10,00809	32
29	9,84553	9,85337	9,99217	10,00783	31
30	9,84566	9,85324	9,99242	10,00758	30
31	9,84579	9,85312	9,99267	10,00733	29
32	9,84592	9,85299	9,99292	10,00707	28
33	9,84605	9,85287	9,99318	10,00682	27
34	9,84617	9,85274	9,99343	10,00657	26
35	9,84630	9,85262	9,99368	10,00632	25
36	9,84643	9,85250	9,99393	10,00606	24
37	9,84655	9,85237	9,99419	10,00581	23
38	9,84669	9,85225	9,99444	10,00556	22
39	9,84682	9,85212	9,99469	10,00531	21
40	9,84694	9,85200	9,99495	10,00505	20
41	9,84707	9,85187	9,99520	10,00480	19
42	9,84720	9,85175	9,99545	10,00455	18
43	9,84733	9,85162	9,99570	10,00429	17
44	9,84745	9,85150	9,99596	10,00404	16
45	9,84758	9,85137	9,99621	10,00379	15
46	9,84771	9,85125	9,99646	10,00354	14
47	9,84784	9,85112	9,99671	10,00328	13
48	9,84796	9,85100	9,99697	10,00303	12
49	9,84809	9,85087	9,99722	10,00278	11
50	9,84822	9,85074	9,99747	10,00253	10
51	9,84834	9,85062	9,99773	10,00207	9
52	9,84847	9,85049	9,99798	10,00202	8
53	9,84860	9,85037	9,99823	10,00177	7
54	9,84873	9,85024	9,99848	10,00152	6
55	9,84885	9,85012	9,99874	10,00126	5
56	9,84898	9,84999	9,99899	10,00101	4
57	9,84911	9,84986	9,99924	10,00076	3
58	9,84923	9,48974	9,99949	10,00050	2
59	9,84936	9,48961	9,99975	10,00025	1
60	9,84948	9,84948	10,0000	10,00000	0
	Co-ſine	Sine	Co-tan.	Tangent	M

45 Degrees

A

TREATISE

OF

MARINE FORTIFICATION.

1. BY MARINE FORTIFICATION, is meant the art of raiſing works fit for the defence of a harbour againſt the attacks of any kind of ſhipping.

As the works proper for this purpoſe depend in a great meaſure on the principles employed in the fortification of towns; therefore it will be neceſſary to give ſome general notions of the uſual methods of fortifying, previous to the meaſures that ſeem moſt effectual to the ſecuring of harbours.

It is not intended in this tract to give a compleat ſyſtem of Fortification; and conſequently the reader will not be perplexed with the different ſyſtems, as they are called, of *ſuch* and *ſuch Engineers*; many of them being only ſuch perſons, as having diverted themſelves with conundrums and whimſical ſcratchings on paper, publiſh'd their conceits for a like amuſement to others; and gravely compared their *pretty drawings* with the approved works of experienced Engineers: It is high time that moſt of their names and notions were forgot, and that thoſe who hereafter may write on this ſubject, ſhould confine themſelves to the deſcription of ſuch works only, as are moſt in uſe, and which by experience have been found to be moſt conducive to the expected defence of the place, and retardation of the approaches of the enemy. And this is what is briefly attempted in the following pages.

PART I.

Of Land Fortifications.

2. Fortification is the art of making certain works about a place, whereby the perſons within may be able to defend themſelves againſt the attacks of a much greater number from without, more effectually and longer than if the place was not furniſhed with ſuch works.

3. Defenſive works uſually conſiſt of moats and banks covering the place which they defend.

4. A place is ſaid to be covered, either when the enemy is prevented from coming to that place by a body of troops or other hindrance: Or, when a ſufficiently ſtrong bank raiſed before that place prevents thoſe without from ſeeing them within.

5. Defenſive works are of various kinds, the moſt ſimple are uſually called lines.

SECTION I.

Of Lines or Intrenchments.

6. A Line, or an Intrenchment, conſiſts of a bank of earth and a ditch, and are of two ſorts.

Firſt, Such as the trenches carried on in a ſiege, where the bank is between the ditch and the enemy or town; and here the earth is thrown up againſt the town, becauſe the workmen are better covered in carrying on the trenches.

Secondly, Such as ſerve to incloſe a town or camp, ſecure a paſs, cover the entrance into a country or other place, *&c.*; in theſe, the ditch is between the bank and the enemy.

The firſt ſort are uſually called trenches or approaches; and the ſecond are generally called lines; which are the ſort that will be here more particularly treated on.

7. Lines are generally made to ſhut up an avenue or entrance to ſome place; the ſides of that entrance being rivers, woods, mountains, moraſſes, or other obſtructions not eaſy to be paſſed by an army: Though there have been caſes where lines were conſtructed in plain countries; but then they were carried quite round the place they were to defend, as the lines ſurrounding a camp, called lines of circumvallation. Lines are likewiſe thrown up to ſtop the progreſs of an army, as thoſe made by Marſhal Villars and others. However, in what follows, it will be ſuppoſed that the line is to cover a paſs that can only be attacked in front.

8. The making of lines greatly depends on the nature of the place, and the time that can be taken to conſtruct them; thoſe done at leiſure being very different from thoſe done in haſt,

The works uſually thrown up in haſt are called *temporary*; they ſerving chiefly on a preſent emergency: Thoſe made at leiſure are generally intended to laſt many years, and are kept in repair under a probability of their being frequently attacked. But whether the work be temporary or laſting, it is neceſſary that it be adapted to the materials at hand, or that can be procured with the leaſt expence and trouble.

A road or paſs may be advantageouſly held by a few men againſt a much greater number, many ways; as by turning a water-courſe, planting of ſtakes, felling of trees, digging of ditches, making a fence of ſtones, &c. But the way now moſt uſually practiſed is, by making a line after ſome ſuch like method as contained in the following precepts.

9. *To throw up a Line acroſs a paſs.*

1ſt. Having choſe the place judged moſt convenient for the line, let a rope, or haybands, or twiſted ſtraw or graſs, be run quite acroſs the way along the intended place of the line, pegging it to the ground at every 4 or 5 yards; and at the diſtance of about 10 or 12 feet before the line, towards the enemy, let ſuch another line, or a row of ſtakes, be carried in a parallel poſition to the firſt rope.

2d. Range the labourers or troops within thoſe limits, either ſingle, in pairs, or treble, &c. according to the number there are to employ, or the time in which the work is to be done, each being furniſhed with proper digging tools.

3d. Let the earth, as they dig it up in this breadth, be thrown on the other ſide of the firſt rope, until a bank of about 5 or 6 feet thick and 6 or 7 feet high be raiſed; obſerving that the ſides of the ditch be ſloped in about the ſame manner as the earth naturally takes in rolling down the bank; and continue the digging till the ditch is about 5 or 6 feet deep, the breadth of the bottom being about $\frac{1}{3}$ of the breadth ſtaked out at top: And while the ditch is digging, if the earth as it is thrown up be trod down, the bank will be more compact; or a few hand-rammers (ſuch as the paviors uſe) kept conſtantly going, will render the work more firm or durable.

4th. Let the inner ſide of the bank be pared with the ſpade into ſuch a ſlope, as a man ſtanding upright may eaſily touch with his arm extended ſtrait before him; and at the foot of this bank, let a *foot-bank* or ſtep be raiſed, of ſuch a height as a man ſtanding on it may eaſily fire his muſket over the bank; that is, let the top of the foot-bank be about four feet and a half lower than the top of the bank or *breaſt-work*.

5th. If there is time and opportunity, let the workmen throw up the looſe and ſcattered earth upon the bank, on both ſides, and ſlap or beat it with the flats of their ſhovels to make it the more neat and compact: Alſo make a gentle ſlope to the top of the *foot-bank*, that the troops may aſcend it the more eaſily; and let the *crown* or *top* of the *breaſt-work* be ſloped ſo, that a muſket laid flat on it may ſtrike the ground with its ſhot about 5 or 6 feet beyond the ditch.

When the ſoil is clay, ſand, turf or mould, the workmen will need only ſpades and ſhovels: When gravelly or ſtony, then one man ſhould break the ground with a pick-axe or mattock, while another throws it upon the bank, where a third ſhould ſpread it level and tread it down.

10. A work of this kind being compleated, the troops behind the *line* may wait the coming of the enemy with leſs concern than without it: For 1ſt, the bank or breaſt-work ſecures them from the enemy's fire; 2d. And when they ſtand on the foot-bank they are more than $\frac{2}{3}$ covered, while the enemy are wholly expoſed; and conſequently the troops within may make three of their ſhots tell for one of the enemy's. 3d. They can, by going off the foot-bank, be quite covered while they load again. And on the whole, they are in no great danger of being forced from the lines while they have courage enough to keep poſſeſſion of them, except the enemy are greatly ſuperior in numbers and cannon.

The magnitude of lines are generally proportioned to the little time that can be ſpared to throw them up, and to the ſtrength of the enemy who are to attack them. The following ſorts are what have been practiſed on ſeveral emergencies, and the rate at which men ordinarily work on ſuch occaſions.

11. *A* TABLE *of the dimenſions of lines.*

Breaſt-work			Ditch			Expence	
Thickneſs at top	Height within	Height without	Upper breadth	Lower breadth	Depth	Solid content	Days works
4 feet	$7\frac{1}{2}$ feet	6 feet	8 ft.	$2\frac{2}{3}$ ft.	5 ft.	$4\frac{2}{3}$ feet	1
5	$7\frac{1}{2}$	6	10	$3\frac{1}{4}$	$5\frac{1}{2}$	$6\frac{1}{12}$	$1\frac{1}{2}$
6	$7\frac{1}{2}$	6	12	4	6	8	2
7	$7\frac{1}{2}$	6	14	$4\frac{2}{3}$	$6\frac{1}{2}$	10	$2\frac{1}{2}$
8	$7\frac{1}{2}$	6	16	$5\frac{1}{3}$	7	12	3
9	$7\frac{1}{2}$	6	18	6	$7\frac{1}{2}$	15	$3\frac{1}{2}$

The days works here, is for one yard in length.

In the firſt, 100 men will compleat 100 yards in length of this kind of lines in one day; 200 men in half a day; 400 men in a quarter of a day; and ſo on.

12. When lines are thrown up at leiſure, then the ditch is uſually 18 feet broad at top, 7 or 8 feet deep, and the ſides of the ditch are ſo ſloped as to leave only 6 feet breadth at bottom; the breaſt-work, or parapet, is about 7 feet thick on the top or crown, and 7 or 8 feet high.

In Plate XII. fig. 1. ſhews the heights, depths and breadths of the ſeveral parts of a line well deſigned and finiſhed.

Where IL repreſents the ground line, or ſurface of the place.
AB, the breadth of the ditch at the top.
CD, the breadth of the ditch at bottom.
FAC, is the ſlope or ſcarpe of the parapet and ditch.
DBK, is the counterſcarpe.
EF, the top or crown of the parapet or breaſt-work.
EG, the inner ſlope of the parapet.
HG, the top of the foot-bank.
HI, the ſlope of the foot-bank.
BKL, a ſmall ſloping bank, called the glacis.

13. *This figure is called a ſection or profile, and may be thus drawn.*

1ſt. In the ground line, lay off from any ſcale of equal parts, the diſtances $Ia = 6$ feet, $ab = 4$ feet, $bc = 1\frac{1}{2}$ ft. $cd = 7$ ft. $dA = 4\frac{1}{2}$ ft. $Af = 6$ feet, $fg = 6$ feet, $gB = 6$ ft. $BL = 5$ ft.

2d. Thro' *a*, *b*, *c*, *d*, *e*, *f*, *g*, B, draw lines perpendicular to IL.

3d. Make $aH = 2\frac{1}{2}$ feet $= bG$, $cE = 7$ ft. $dF = 6$ ft. $fC = 8$ ft. $= gD$.

4th. Draw IH, HG, GE, EF, FAC, CD, DB, which continue till it meets the line FL, and the profile is conſtructed.

14. When lines are made to cover a camp or a large tract of land where a conſiderable body of troops are poſted, the work is not made in one ſtrait, or uniformly bending line: But at certain diſtances the lines project in ſaliant angles towards the enemy. Theſe projections, or ſaliant angles are called REDENTS or FLANKERS; becauſe the fire from them take the enemy in flank or ſideways as they march to attack the lines.

The diſtance between the ſaliant angles of the *flankers* is uſually between the limits of 200 and 260 yards, the ordinary flight of a muſket ball, point blank, being generally within thoſe limits; altho' muſkets a very little elevated will do effectual ſervice at the diſtance of 360 yards.

15. A flanker conſiſts of two lines called faces, meeting in a point, and forming an angle called the *ſaliant angle*, or *flanked angle*.

That part of the line between two adjacent flankers is called the *curtin*.

The *gorge* of a flanker is the diſtance between its faces taken at their interſection with the curtin.

16. In Plate XII. fig. 2 ſhews the form of the uſual lines; where the figures CAB, *c a b*, are redents or flankers.

AC, AB, *a c*, *a b*,	the faces.
CB, *c b*,	the gorges.
AD, *a d*,	the capitals.
B *b*	the curtin.
The angle CAB, *c a b*,	the ſaliant or flanked angle.

The diſtance of the ſaliant angles is about 240 yards on a mean.
The length of the capital is uſually between 40 and 50 yards.
The length of the gorges is alſo about 60 or 70 yards.

17. *To make a Plan of lines with redents.* Plate XII. Fig. 3.

1ſt. Let the line EEEE, *&c.* be ſo drawn, if poſſible, that wherever there is a bend or angle, it may either be at once, or twice, or thrice, *&c.* the length of about 240 yards one from another, whereby a redent will always be where there is an angle.

2d. In this line lay off diſtances of 240 yards each, as from E to E, E to E, *&c.* reckoning from the bends towards each end, whether it happens that the line will, or will not be exactly meaſured by a repetition of the 240 yards.

3d. At each point E draw the *capital* EF in a perpendicular poſition to the direction of the line in that point, and make the *capitals* about 40 or 50 yards long.

4th. On each ſide of E take the *half gorge* EG, EG, each of about 30 or 35 yards, and draw the *faces* FG, FG; and the out-line, or *maſter-line* of the curtins and redents are formed.

5th. Parallel to each *curtin* and *face* draw lines within, at the diſtances from the *maſter-line* of 7 feet, 8 feet, 12 feet, and 18 feet.

Then the breadth of 7 feet repreſents the plan of the *parapet*.
of 1 foot its inner ſlope.
of 4 feet the top of the *foot-bank*.
of 6 feet the foot-bank ſlope.

6th. On the outſide of the *maſter-line*, draw lines at the diſtances of $10\frac{1}{2}$, $16\frac{1}{2}$, and $22\frac{1}{2}$ feet, parallel to each curtin and face; and theſe will repreſent the plans of the *ſcarpe*, *ditch*, and *counterſcarpe*; obſerving that the ſaliant angles of the counterſcarpe are rounded before the angles of the redents.

When plans are drawn from a large ſcale, all the lines beforementioned are drawn: But when the plan is drawn from a ſmall ſcale, as of 20 yards or more to an inch, then the plan is uſually repreſented by four parallel lines; one without the maſter-line, repreſenting the counterſcarpe or out-line of the *ditch*; and two within, repreſenting the breadths of the *parapet* and *foot-bank*.

Sometimes a ſhort line is haſtily formed by a CHEVEAUX DE FRISE; which is a beam of 6 or 8 inches ſquare and 10 or 12 feet long; the ſides being bored thro' with holes about an inch and half diameter, and 6 inches diſtant from one another; thro' each hole goes a ſtaff of about 5 or 6 feet long, armed at both ends with an iron ſpike, ſo that whichever way it is laid along, one row of pikes is preſented againſt the enemy: A line is formed of theſe pieces by chaining together a ſufficient number of them end to end.

SECTION II.

18. Of Batteries.

When lines are to be vigorouſly defended againſt a potent enemy, it is proper to raiſe *batteries*, that is, works from whence cannon may play on the troops as they advance to the attack: Theſe batteries are either *open* or *covered*.

19. An Open battery is nothing more than a number of cannon, generally *field pieces* (that is, ſuch as carry a ball not exceeding 9 pounds weight) ranged in a line or row abreaſt of one another, on ſome natural ſmall elevation of the ground; or on an artificial bank of about a yard or two high: Theſe cannon are ranged at about 15 or 16 feet diſtant from one another, having their ſhot and loading utenſils lying by their ſide, and the powder lodged in a hole at ſome diſtance behind the battery. A leſs diſtance than about 15 feet from gun to gun, might occaſion danger, conſidering the hot ſervice for which ſuch batteries are erected.

20. A Cover'd battery is when the cannon and gunners are covered by a bank made of bruſhwood, faggots and earth; of about 18 or or 20 feet thick, and 7 or 8 feet high. The cannon uſed in ſuch batteries are generally from 9 to 18 pounders; and ſometimes 24 pounders are uſed in them.

21. The faggots, or, as they are moſt uſually called, the Fascines, are made of the middling ſized loppings of trees, under an inch diameter, and are of three different lengths, 6, 9 and 12 feet, according to the work they are intended for: They are uſually bound or tied round with wyths; the ſhorteſt in two places, the next in three, and the longeſt have four bands. Theſe faſcines are commonly 8 or 9 inches thick throughout, the ends being cut ſo as not to be tapering.

The faſcines are fixed to the ground, and to one another by ſtakes called Pickets, like birch broom-ſticks, but ſtronger; they are about an inch, or inch and half thick, and from 3 to 6 feet long: The 6 feet ones are in number about $\frac{2}{3}$ of the 3 feet pickets, but much ſtronger.

All *field batteries* conſiſt of four chief parts, namely, the *ditch*, the *parapet*, the *platform*, and the *magazine*.

22. Of the Ditch.

The ditch is uſually dug in the front and ſides, and ſometimes quite round; and ſerves not only to furniſh the earth neceſſary for the parapet, but it alſo prevents the enemy from entering the battery ſo readily as he might otherwiſe do. The ditch in front is commonly 18 or 20 feet broad, and the depth about 7 or 8 feet; the ſides ſloping towards the bottom, which is about 6 feet wide: But the ditches on the ſides are about 10 feet wide, and 6 feet deep. Theſe are the dimenſions uſually given; but the general practice ſeems to be, only to get earth ſufficient for the work, and not mind the regularity of the ditch: For as theſe works in attacks are uſually done by night, the keeping ſtrictly to the aſſigned dimenſions is hardly practicable.

23. *Of the Parapet.*

The parapet is generally raiſed about 3 or 4 feet diſtant from the brink of the ditch, the ſpace left between, called the BERM or FORELAND, ſerving to lodge the rubbiſh beat down by the enemy's ſhot, that it may not fall into the ditch.

The thickneſs of the parapet ſhould be about 18 or 20 feet, in order to be cannon proof, and about 7 or 8 feet high when the enemy has no command above the battery: But if they have a command over this height, the parapet ſhould be raiſed high enough to cover the men while they load the guns.

The length of the parapet depends on the number of guns to be employed in the battery.

24. Thus for one gun, allow 8 yards in length.

And 6 yards more for every other gun.

So 2 guns has 14 yards; 3 guns 20 yards; 4 guns 26 yards, *&c.*

25. There ſhould be great care taken that the battery be not *enfiladed* or *raked* by the enemy's cannon: Neglects of this kind are often fatal to the officers and gunners, as was well known at the ſiege of Carthagena, anno 1741. But this is eaſily prevented by raiſing at one, or both ends of the parapet, a bank acroſs the battery called an *epaulment*, of the ſame thickneſs and height with the parapet, and about 15 or 18 feet long.

26. The parapet conſiſts of two parts, namely, the *wall* and the *merlons*.

The WALL is that part of the parapet which is contained in one piece from end to end, and is about $2\frac{1}{2}$ or 3 feet high.

The MERLONS are detached pieces of the parapet, leaving openings called EMBRASURES, thro' which the cannon deliver their ſhot.

The embraſures ſhould as much as is poſſible be cut perpendicular to the parapet; therefore the battery ſhould be parallel, or nearly ſo, to the object to be battered: For the direct ſhots have moſt force; and oblique embraſures weaken the merlons, or parts of the parapet ſtanding between the embraſures.

27. The embraſures are uſually about 2 or $2\frac{1}{2}$ feet wide on the inſide, and about 9 or 10 feet on the outſide; whereby the cannon may be traverſed from the right to the left, ſo as to command a pretty large extent in front. The diſtance from the middle of one embraſure to the middle of the next ſhould be about 18 feet, in order to leave ſufficient room for the working of the guns, and the ſtowage of the ſhot and other neceſſaries.

28. *Of the Platform.*

The PLATFORM is a floor made to facilitate the rolling of the carriage wheels, and to prevent them from ſinking into the ground by the weight of the cannon, eſpecially in wet weather.

Platforms are generally laid ſloping towards the parapet 9 or 10 inches; this carries off the rain, prevents the gun from recoiling ſo much when fired as it would do if laid level; and when loaded, it is more eaſily brought to the embraſure.

29. In temporary batteries, the platforms are made of planks laid acroſs ſome ground timbers or ſleepers: There is uſually a platform made to each gun; it is about 18 feet long, 8 feet broad next the parapet, and about 14 feet broad at the tail, the intermediate ſpaces between the platforms ſerving for the ſhot and other neceſſaries.

30. When a platform is to be laid on marſhy ground; firſt lay a floor or two of faſcines; cover theſe with *hurdles* of 12 or 15 feet long, and 6 or 7 broad; on theſe lay a floor of 3 or 4 inches of earth, and therein lay the ſleepers, and over them the planks.

31. When a battery is built of ſtone or brick, the platform is generally a flat-ſtone pavement ranging the whole length of the battery: This, on account of its reſiſting the injuries of the weather for a long time, is to be preferred to planks; but in caſe of a bombardment ſuch a platform is to be avoided, becauſe the ſhells will not only break the pavement, but alſo by driving about the broken ſtones, do the troops much miſchief.

32. *Of the Magazine.*

The magazine to a field battery is uſually made about 50 or 60 yards behind the platform: It is a cavity dug in the ground about 4 feet deep; the earth whereof is thrown between the pit and the platform; the ſides of the pit are ſometimes planked round to keep it dry, and prevent the earth from crumbling in; and the powder barrels placed herein are covered with hurdles and earth, or tanned hides, to preſerve the powder from wet and fire.

The communication to the magazine is by a ſloping trench beginning to deſcend about 5 or 6 yards behind the platform; and the earth thrown on that ſide where it will moſt conveniently cover the perſons who remove the barrels of powder from the great magazine to the battery, or ſmall magazine.

33. When there are many cannon in battery, and the ſervice is quick, it is cuſtomary to have to every two pieces a ſmall magazine to hold 20 or 30 barrels of powder: This is placed about 15 or 20 yards behind the platform, and againſt the merlon between the cannon; and as theſe barrels are uſed, they are replaced by others from the great magazine.

At each magazine a centinel is placed to prevent accidents.

And to prevent perſons coming into the battery and magazines who have no buſineſs there, a trench is ſometimes dug behind the magazine, and carried into the trenches which communicate between the magazine and battery.

34. *To conſtruct a Faſcine battery.*

For one gun provide faſcines of 9 feet, 600; of 6 feet, 100; of 3 feet, 120.
And for every other piece 400; 100; 100;
each faſcine being about 9 inches thick; and let there be three or four pickets for every faſcine, for many will break in driving.

Trace the limits of the parapet in two parallel lines about 18 feet diſtant, allowing 8 yards in length for one gun, and 6 yards for every other gun; and along theſe lines cut a trench about half ſpade deep.

Lay a row of 9 feet faſcines along one trench, obſerving that their ends be well jammed one into the other, and let each be pegg'd down with two pickets, drove into the ground till the head is ſunk into the faſcine.

Cloſe to this row lay another, letting the two end ones be of 6 feet, and the reſt 9 feet, whereby the joinings in this row will not fall againſt the joinings in the firſt row: Let theſe be alſo ſtaked down as before. Cloſe to the ſecond row lay a third all of 9 feet. Cloſe to the third lay a fourth, the two end ones being 6 feet, and the reſt 9 feet. In this manner lay the rows of faſcines within the limits ſtaked out, which will be covered with 24 rows; then over this floor of faſcines ſprinkle earth to fill up the hollows, and let the whole be trod or rammed down.

On the firſt floor lay a ſecond, obſerving, that as in the firſt floor every ſecond row ended with 6 feet faſcines, ſo in the ſecond floor let every odd row end with 6 feet ones, whereby the joinings of no two faſcines in this floor will fall over the joining of the faſcines below them. Let the outſide rows in the ſecond floor be ſo placed over thoſe in the lower, that there be a little ſloping preſerved, the work narrowing upwards. The pickets which ſtake down this floor are to be drove up to the head, and the channels or hollows in the floor are to be filled up with earth. In this manner lay four floors, which will raiſe the work to about $2\frac{1}{2}$ or 3 feet; and that part of the breaſt-work called the wall will be compleated.

35. *To ſtake out the Merlons.*

Meaſure from each end of the wall 12 feet, there ſtick a ſtake; and plant other ſtakes at every intermediate 18 feet: This being done on the inſide of the wall, let other ſtakes be planted on the outſide, either directly oppoſite the former, or in the line towards the place where the gun is more particularly intended to deliver its ſhot. Plant other ſtakes on the inſide, one a foot diſtant on each ſide the former, and this will leave ſpaces of two feet each for the inner opening of the embraſures: Then on the outſide, plant other ſtakes at 5 or 6 feet diſtance from the former ones, one on each ſide, and ſpaces of 10 or 12 feet will be marked out for the outſide openings of the embraſures.

In the direction of the pickets which limit the inner and outer openings of the embraſures, let ſingle rows of faſcines be ſtaked down acroſs the wall, and theſe will be the ſides of the embraſures: Fill the intermediate ſpaces or merlons with rows of faſcines laid lengthwiſe to the wall, and this will be the firſt floor of the merlon, which is to be picketted down, and the hollows filled with earth as before directed. Let other floors be raiſed in like manner, until the merlons are carried up to about 5 or 6 feet, or more if neceſſary; and on the top of each let a bed or floor of earth be laid of about 8 or 12 inches thick.

Acroſs the top of the inner opening of the embraſure, either lay a bundle of 10 or 12 faſcines bound together, or as many ſtuft into a kind of baſket open at both ends, and the bundle well ſtaked to the merlons.

Provide a *blind* made of planks 3 or 4 inches thick, to fit the inner opening of the embraſure, which is to be put up while the gunners are loading the piece, to preſerve them from the fire of the muſketry.

The cheeks or ſides of the embraſures are to ſlope ſo, as to have the top wider than the bottom; which not only leaves a greater opening for the blaſt of the gun, but theſe ſlopes in works of this kind give a greater degree of ſtrength to ſupport themſelves againſt the thruſt of the upper parts.

36. *To conſtruct the Platforms.*

Againſt each embraſure lay on the ground five pieces of timber called ſleepers, of about 18 feet long and 6 or 8 inches ſquare; let the ends next the embraſure be placed at ſuch a diſtance from one another, that the diſtance from out to out be about 6 feet, the other ends ſpreading about 12 or 14 feet from out to out; drive two ſtakes of about 3 inches ſquare into the ground on both ſides of each end of every ſleeper, whereby they will be kept ſteady in their places, and let the earth be well rammed and beat up cloſe to them: But obſerve to let the tails of the ſleepers be raiſed about 6 or 8 inches higher than the ends next the wall, to prevent the cannon from recoiling too much when fired.

Cover the ſleepers with planks of about 2 inches thick laid croſswiſe; that next the embraſures being about 8 feet long, the reſt gradually increaſing, ſo that the plank at the tail be about 14 feet long, and let the planks be nailed to the ſleepers.

On this floor fix a piece of timber of about 6 or 8 inches ſquare next the embraſure, to ſerve as a ſpur for the carriage wheels to knock againſt (and is therefore uſually called the *knocker)*, when the gun is run up to the wall; obſerving that the ſpur be laid parallel to the object to be battered.

The whole platform ſhould be of oak, if it can be had.

37. If there is any danger of the battery's being raked by the enemy's cannon, let an *epaulment* or *ſcreen* be raiſed at one or both ends of the parapet, joining to it, and conſtructed by floors of faſcines as before ſhewn: Then all the ſtragling twigs of the faſcines being cut off, the battery is conſtructed.

A battery thus made will do in caſe of haſt, and where earth enough is not eaſily had: But as it is ſubject to be fired when the wood is dry, it is not ſo much in uſe as another ſort called a Coffer battery; eſpecially where wood is ſcarce and earth plenty.

A Coffer battery is that where the ſides of the wall and merlons only are formed of faſcines, and all the cavities or included ſpaces filled with earth.

38. *To make a Coffer battery.*

The place of the battery being determined, mark out with a line of ſome kind, the limits of the parapet of about 18 or 20 feet thick; and 3 or 4 feet before the parapet, mark out with lines or ſtakes, the limits of the ditch of about 10 or 12 feet broad, or more if earth is wanted; allowing 8 yards in length for one gun, and 6 yards more for every other gun.

On the outlines of the parapet, cut a trench of about 5 or 6 inches wide and deep, and therein lay a row of faſcines, the ends being jammed one into the other; let theſe be ſtaked down: Lay on them another row, ſo that the joinings of theſe be not directly over the joinings of the lower one, and the knots of all the bands turned inwards, ſtake theſe down; and on them lay in like manner a third and a fourth row, &c. until the height be about 3 feet. The ſame kind of work being done at the ends, and for the epaulment if wanted, the coffer for the wall will be made.

Then let the men be diſpoſed along the place intended for the ditch, and with the proper tools break the ground and throw it into the coffer; where another ſet of men are, as the earth is thrown in, to ſpread it and ſtamp it down with rammers; and this work is to be continued until the coffer is filled.

39. When the wall is finiſhed, let the embraſures be ſtaked out as before (35), and a coffer formed in like manner, as for the wall, for each merlon, which is alſo to be filled with earth and rammed down.

The other articles in the preceding battery are to be followed in this, the only difference being in the making of the parapet.

When a proper place for a temporary battery is deſtitute both of dry earth and wood, then materials muſt be carried to the place; theſe uſually are *gabions* and *earth-ſacks*.

The Earth-sacks are only bags to carry earth in.

A Gabion is a large baſket without a bottom: They are of various ſizes, as from 3 feet high and 2½ or 3 feet diameter, to 6 or 8 feet high and 6 or 7 feet diameter.

40. *To make a Gabion battery.*

Along the line pitch'd out for the battery, let the gabions be planted in the places where the merlons are to be: The gabions uſed are of 5, 6 and 7 feet diameter, and 8 feet high. Each merlon muſt have 7; that is, 3 within of 6 feet diameter, next two of 7 feet diameter, and on the outſide two of 5 feet diameter; obſerving to leave proper openings for the embraſures, of about 2 feet on the inſide, and 9 or 10 on the outſide.

Or thus: Let the merlons be made of gabions 5 feet diameter; then put four within, three in the middle, and two on the outſide; this conſtruction being rather ſtronger than the former.

The ends and epaulments are alſo formed by three rows of gabions.

The floors or bottoms of the embraſures are to be filled with gabions of about three feet high, and of a proper diameter to fill up the ſpaces between the merlons.

The gabions being placed, they are to be filled with earth brought, from the neareſt places that will afford it, in the earth-ſacks; or elſe they may be filled with dung mingled with ſand; and in caſes of neceſſity, they may be filled with large faggots, or billet wood, obſerving that the voids between the gabions are alſo filled.

Batteries of this conſtruction are uſually made on marſhy or rocky ground.

41. The *Sieur Remy*, in his Memoirs of Artillery, has given a table for the ready finding of all the requiſites for the conſtruction of temporary batteries, and for their daily ſervice, the pieces being 24 pounders; and although theſe batteries are calculated only for ſieges, and are of the coffer-kind, yet from this table may be derived ſuch notions as will greatly help young artiſts on other occaſions.

It is alſo proper to mention the number of faſcines and pickets that is uſually expected every day from the labour of each man employed in that ſervice.

Faſcines of 5 or 6 feet long, and 5 or 6 inches thick, bound with two wyth bands each, one man will make 16 or 18 in a day, with two pickets to each.

Faſcines of 8 or 9 feet long by 8 or 9 inches thick, and two pickets to each, one man uſually makes 10 or 12 in a day.

Faſcines of 12 feet long by 9 inches thick, with three pickets to each, 8 or 10 ſuch are uſually expected for one man's day's work.

The days here underſtood are ſuch wherein the men may work about 12 hours.

In the following table C ſtands for hundred.

42. *A* Table *for conſtructing of Batteries.*

Number of 24 pounders in battery.	Length of the parapet in yards.	Number of workmen to conſtruct the battery.	Number of workmens tools uſed at the battery, *viz.* ſhovels, ſpades, pick axes, mattocks, &c.	Faſcine-makers, each a bill and hatchet.	Faſcines of 8 or 9 feet by 8 or 9 inches.	Faſcines of 12 feet by 8 or 9 inches.	Faſcines of 5 or 6 feet by 5 or 6 inches, made by the cavalry.	Pickets from 3 to 6 feet long, and about 1½ inch thick.	Mallets to drive the pickets.	Handbills, 2 for each embraſure, beſide ſpare hatches.	Planks for the platforms, of 2 or 2½ inches thick.	Gunners to ſerve in the battery.	Soldiers to aſſiſt the gunners.	Powder for 100 rounds, at 12 lb. each, per day.	Shot of 24 pounds for 100 rounds.
2	14	50	70	15	120	40	2 C	520	10	4	32	4	12	24 C	2 C
3	20	60	85	20	165	60	3 C	740	14	6	48	6	18	36 C	3 C
4	26	70	100	25	210	80	4 C	960	18	8	64	8	24	48 C	4 C
5	32	80	115	30	255	100	5 C	1180	22	10	80	10	30	60 C	5 C
6	38	90	130	35	300	120	6 C	1400	26	12	96	12	36	72 C	6 C
7	44	100	145	40	345	140	7 C	1620	30	14	112	14	42	84 C	7 C
8	50	110	160	45	390	160	8 C	1840	34	16	128	16	48	96 C	8 C
9	56	120	175	50	435	180	9 C	2060	38	18	144	18	54	108 C	9 C
10	62	130	190	55	480	200	10 C	2280	42	20	160	20	60	120 C	10 C
11	68	140	205	60	525	220	11 C	2500	46	22	176	22	66	132 C	11 C
12	74	150	220	65	570	240	12 C	2720	50	24	192	24	72	144 C	12 C
13	80	160	235	70	615	260	13 C	2940	54	26	208	26	78	156 C	13 C
14	86	170	250	75	660	280	14 C	3160	58	28	224	28	84	108 C	14 C
15	92	180	265	80	705	300	15 C	3380	62	30	240	30	90	180 C	15 C
16	98	190	280	85	750	320	16 C	3600	66	32	256	32	96	192 C	16 C

43. When batteries are erected at leiſure, and wanted to ſtand for ſome years, then it is beſt to make them of ſtone or brick, or good loamy earth, according as the materials are neareſt at hand, or can be moſt eaſily procured.

When made of ſtone, the thickneſs of the parapet is uſually about 4 or 5 feet: But this thickneſs is varied according to the quality of the ſtone, or to the ſize of the cannon that may be brought by an enemy to fire on it.

Parapets of brick, are of 5, 6, 8, or even 10 feet thickneſs, according to the goodneſs of the materials, or the ſervice it is to endure; and the angles are generally of ſtone.

A parapet made of good earth, and 18 or 20 feet thick, with the ſurface covered with green turf, will reſiſt the injuries of the weather for ſeveral years, and ſtand the ſhock of an enemy's cannon the beſt of any.

44. As theſe perpetual batteries are generally raiſed ſomewhat above the level of the adjacent land or water which they are to command; ſo it is uſual to make the floor of the embraſures ſloping, the drip being on the outſide, about a foot or foot and half below the ſill of the inner opening, whereby the cannon may be pointed downwards.

When the embraſures are cut thro' an earthen parapet, they are commonly lined with brick; or at leaſt the angles are made of maſonry, theſe parts being the moſt ſubject to be injured by the weather.

The beſt embraſures are thoſe made with a neck, whereby a part of the opening becomes more contracted, and conſequently is better adapted to preſerve the gunners and cannon from the enemy's ſhot, than when the cheeks of the embraſures are made ſtrait.

45. Altho' the axis or middle line of an embraſure ſhould, if poſſible, be at right angles to the length of the parapet, yet it may ſometimes be neceſſary to have them oblique: When this happens, the inſide of the parapet is notched, or ſo cut away, to leave proper room for the front of the platform, that the wheels of the carriage may be drawn up againſt the inner opening for the axis of the gun to lie in the axis of the embraſure: But then the outſide of the parapet is to be ſtrengthened, to compenſate for what is cut away within.

The foregoing particulars, relating to embraſures, will be ſufficiently illuſtrated by the following precepts for their conſtruction.

46. *To conſtruct the Plans of embraſures.*

FIRST. *For the Plain embraſure.* Plate XII. Fig. 4.

1ſt. Draw the axis AB perpendicular to the parapet.
2d. For the front opening, make AC = AD, each from 4 to 5 feet.
3d. For the inner opening, make BF = BE, each from $1\frac{1}{2}$ to 2 feet.
4th. Draw FD, EC, for the cheeks of the embraſure required.

47. SECONDLY. *For the neck'd embraſures.* Plate XII. Fig. 5.

1ſt. Having drawn the cheeks for a plain embraſure as before; then from B, the middle of the inner opening, draw BC, BD.

2d. In the axis AB, take BG = $2\frac{1}{2}$ or 3 feet; thro' G draw IH at right angles to BA, cutting BC, BD, in H, I, and join EH, FI.

Then DIF, CHE, are the angular cheeks, IH being the neck or narrowing of the embraſure.

48. THIRDLY. *For an oblique embraſure.* Plate XII. Fig. 6.

1ſt. Draw the axis *a b* in the direction where the gun is to command, and thro' any convenient point I, taken in *a b*, draw NN at right angles to *a b*.

2d. Make IN = 4 or 5 feet for the front opening, IP = $1\frac{1}{4}$ or 2 feet for the inner opening, and IQ = 4 feet for the front of the platform.

3d. Thro' N, P, Q, and parallel to *a b*, draw NC, ND, cutting the front of the parapet in C, D; and P *p*, Q *q*, cutting the inſide of the parapet in *q*, *q*.

4th. Thro' *q* draw *q r* parallel to NN, cutting the former lines in F, B, E, *r*; join ED, FC, and draw *r s* parallel to a line thro' B and C:

Then the ſpace *q r s* being cut away, the wheels of the carriage can knock againſt the line *q r*, and the axis of the gun will lie in the line B *a* intended for the axis of the embraſure.

It is evident that the parapet is conſiderably weakened by the cuts for theſe oblique embraſures, and therefore ſhould be ſtrengthened on the outſide.

49. *When the embraſures are to be expreſſed in the parapets of a plan drawn from a ſmall ſcale, it is done thus.* Plate XII. Fig. 8.

On the inſide of the parapet RS, lay off as many times 6 yards, in the points *c*, *c*, *c*, &c. as the length of the parapet will admit, unleſs reſtrained by particular circumſtances; and from the points *c*, *c*, *c*, &c. draw lines to the front of the parapet, dividing it into parts of 3 yards each; then taking the parts oppoſite the points *c* for the fronts of the embraſures, the other parts will repreſent the fronts of the merlons.

Shade all the merlons, leaving white angular ſpaces to expreſs the embraſures, and ſtrengthen the inner line of the parapet and the front lines of the merlons.

50. *Of the Profiles of batteries.* Plate XII. Fig. 7.

Let the ground line of the battery be AB, BD that of the parapet, whoſe inner ſlope DH, if formed by making D *a* = $1\frac{1}{2}$ feet, and the perpendicular *a* H = 6 or 7 feet; the crown of the parapet HI is formed by making *b* I a foot or two lower than *a* H; and the front of the battery IB is found by making *b* B = $\frac{2}{3}$ *b* I, when of earth, or = $\frac{1}{6}$ of *b* I when of maſonry. Make DC = $2\frac{1}{2}$ or 3 feet, gives C the ſill of the embraſure, whoſe floor CG is to drip a foot or two below the level line CF.

The platform DE is 18 or 20 foot, the tail E riſing about 6 inches above the level line AB, the lower double line repreſents the ſleeper laid lengthwiſe, and the upper double line ſhaded with the lines acroſs, expreſs the ends of the planks laid on the ſleepers.

A gun on its carriage, with the wheels againſt the knocker at D, is annexed to the figure, to ſtrengthen the learner's notions.

SECTION III.

Of additional works.

51. Of Ramps.

When a battery is raiſed above the level of the ground it is built on, there muſt be made gentle ſlopes for the cannon to be drawn up and down by, and alſo for the eaſy communication of the troops poſted there; theſe ſlopes, to diſtinguiſh them from the ſlope uſually given to elevated works for their better ſecurity of ſtanding, are called *Ramps*.

The baſe of the ſlope commonly given to earth-banks for their ſupport, is on the inſide about a foot baſe for a foot of height, and on the outſide is about 8 inches on a foot, or $\frac{2}{3}$ of the height; that is, they riſe 12 inches, on 8 inches of baſe: But for the ſlopes of ramps, the riſe is only about 2 inches on 12, or the length of the ramp's baſe is ſix times the height, and this is general, for the draught of carriages: But foot-ways need not be of ſo gentle a ſlope, a riſe of one foot in three may do well enough; or, inſtead of ramps, ſtairs may be, and commonly are, uſed for the paſſage of the foot.

The breadth of a carriage-ramp is uſually about 9 or 10 feet, that breadth being ſufficient for the carriage and foot-way beſide: But thoſe for foot-paſſage only, need not be above 3 or 4 feet wide.

Ramps may either riſe on the ſide of an elevated work, or againſt a ſaliant angle of that work; their repreſentations in plans may be expreſſed as in the following conſtructions.

52. *To conſtruct a Ramp on the ſide of a bank.* Plate XII. Fig. 9.

Let XX, ZZ, be lines expreſſing in a plan, the ſlope of a bank equal to its height, which ſuppoſe to be 12 feet.

1ſt. Thro' A, the point aſſigned where the ramp is to end, draw CB perpendicular to XX, and make AC of about 10 feet.

2d. In ZZ take BD = 4 times AB, or 8 yards; thro' D draw AE, and thro' C draw CF parallel to AE, cutting XX in G, and ZZ in F.

3d. Thro' F draw, at right angles to GF, the line *f*E cutting XX in *f*, and AE in E; join BE, and the lines GF, EA, EB expreſs the ramp.

It is ſometimes proper to have ramps riſe on either hand for the convenience of carriages coming from the right or left; but they muſt then be ſo far aſunder, that ſhould a carriage be drawing up each at the ſame time, the horſes of one may paſs clear of thoſe of the other.

To conſtruct a Ramp in a ſaliant angle of a bank. Plate XII. Fig. 10.

53. First method. This is done in the ſame manner as in the ſide of a bank; obſerving that the end A is taken 6 or 7 yards from the ſaliant angle, when a ramp is to be conſtructed on both ſides; otherwiſe the ramp may end at the ſaliant angle X.

54. SECOND METHOD. Fig. 11. 1ſt. From X draw a line XN biſecting the ſaliant angle; make XN = 6 times the height, or equal to 12 yards, and on both ſides draw a parallel line QR at the diſtance from XN of half the breadth of the way; ſuppoſe at 5 feet diſtance from XN.

2d. Biſect the angle XQR with the line QY, cutting the line ZZ in Y; join YR, and the plan is formed.

55. THIRD METHOD. Fig. 12. From X the ſaliant angle, with a radius of 6 times the height, ſuppoſe of 12 yards, deſcribe the arc LL; and with 5 times the height, or 10 yards, deſcribe the arc KK, cutting ZI in O, and draw OP parallel to KL.

Make XM = 2 or 3 yards, and draw the curved lines MO, MP, which in plans are beſt done by hand; or elſe draw right lines from M to O, and from M to P, and the plan of the ramp is made.

56. *Of Barbets.*

It often happens that by raiſing the floor of part of a battery, the guns placed thereon have an advantageous command over ſome part of the neighbourhood; and when the guns thus raiſed fire over the crown of the parapet without any embraſures, it is called an OPEN BATTERY, or *Battery en barbe*, or plainly a BARBET.

Theſe barbets may be made either in a curtin, or at the ſaliant angle of a flanker: They always ſhould be 2½ or 3 feet lower than the crown of the parapet, be about 8 or 9 yards broad at top, with a proper ſlope to the baſe, of a length proper for the number of guns to be mounted on them, allowing about 5 or 6 yards for each, and aſcended at each end by a proper *ramp*.

57. To give a farther illuſtration to this article, here is added an explanation of the plan, and of the profile thro' the line BC. Plate XII. Fig. 13, 14, 15.

Let PQRVX be a common bank of a line, whoſe parapet is RSTV; the inner ſlope RS being about 6 or 7 feet higher than QR: Then the bank *mno* R, raiſed ſo high that the cannon can fire over the crown of the parapet ST, is the *barbet*, whoſe height *np* is about 3 or 4 feet.

On the top of the barbet a platform is raiſed as in other batteries.

Let the figs. 14, 15, repreſent part of the plan of a line, and one of its flankers, or of a battery conſtructed in ſuch a form; where A *a* is the length of the barbet or raiſed battery, ſuited to the number of guns to be uſed, which are to be drawn up the ramps put at the ends; the breadths being about 8 or 9 feet, and the length *a b* about 7 or 8 yards.

58. *Of Cavaliers.*

A cavalier is a battery raiſed above the other works, and covered by a parapet with embraſures.

Cavaliers are of various ſhapes, ſuch as ſquare (Plate XII.) fig. 17, or round, fig. 16, or like a horſe-ſhoe, or a plain line; but when they are conſtructed in flankers, as is uſually the caſe, fig. 18, they are of a like figure to that flanker; leaving a ſpace of about 8 or 10 yards, or more, between the parapet of the flanker and the outline of the cavalier.

They ſhould be faced with earth, or plank or brick, but not with ſtone, becauſe the ſplinters knock'd off by the enemy's cannon would greatly annoy the troops that may be poſted in the line below the cavalier.

Any other particulars will be ſufficiently known from the figures; obſerving, in the plans, to repreſent their outſide limits by a double line, to expreſs the ſloping of the earth, and to put a ramp in the gorge.

59. *Of Traverſes.*

A traverſe is a bank of earth thrown perpendicularly acroſs a line, or other work, to prevent the enemy's cannon from raking that line.

Theſe traverſes may be from 12 to 18 feet thick, in order to be cannon proof, and their height about 6 or 7 feet, or more if the line is expoſed to any eminence from whence the enemy has a command.

And to preſerve a communication, a paſſage of about 5 or 6 feet wide muſt be left at one end of the traverſe.

60. The different ways of conſtructing theſe works are readily ſeen by the figures in Plate XII. fig. 19, 20, 21, 22.

Thus at A, fig. 19, it is formed by two equal ſhort banks, whoſe ends jut one beyond the other about 3 or 4 feet, leaving a paſſage of about 6 feet.

At B, C, and figs. 20, 21, the end of the traverſe juts about 2 or 3 feet into the parapet, beſide the paſſage: But as this greatly weakens the parapet, it is to be practiſed only in ſuch places where there is ſufficient thickneſs left; and where nothing can be ſpared from the parapet, the traverſe may be made as at E and F, fig. 22.

If any part of a work, thus ſhut in by one or more traverſes, is likely to be defended by the muſketry, then it is proper to add to the traverſe one or more foot-banks within the defence, for the troops to mount on when they want to fire over the traverſe, leaving the upper foot-bank $4\frac{1}{2}$ feet below the crown of the traverſe.

61. *Of Paliſades.*

Paliſades are ſtrait wooden ſtakes of about 9 or 10 feet long and about the thickneſs of a middling ſized leg, but of a triangular or rectangular ſhape, and have one of their ends pointed. Their uſe is to form a line before thoſe places that are moſt likely to be taken by ſurprize.

The beſt are thoſe made of oak, but where this is wanted, or on emergent occaſions, the beſt are thoſe which can moſt conveniently be procured.

In planting of paliſades, it is uſual to ſink about three feet of them into the ground, the thick end downwards, and to ſet them about four inches from one another; the whole is braced together by pieces nailed acroſs them near the tops, and ſecured by thick poſts at the diſtance of every four or five yards.

Paliſades are found to be a very good defence againſt an enemy not greatly ſuperior, and deſtitute of cannon; for the defendants may freely uſe their ſmall arms at the time they are half covered by the paliſades; whereas the aſſailants being quite expoſed, attack with the diſadvantage of, at leaſt, one to two.

62. *Of Barriers.*

A barrier is a kind of fence or gate ſerving to ſhut up the roads or paſſages in works of any kind, to prevent their being carried by ſurprize, and are of various kinds, as

1ſt. A ſtrong chain drawn acroſs the paſſage, at about $3\frac{1}{2}$ or 4 feet above the ground, and faſtened at each end to an upright poſt.

2d. A beam laid horizontally acroſs two upright poſts.

3d. A BAR-GATE hanging by hinges to an upright poſt.

4th. A CHEVEAUX DE FRISE, which is a horizontal beam uſually cut into 6 ſides, each whereof is armed with iron ſpikes ſet within five or ſix inches one of the other: This beam is ſupported at each end by an upright poſt.

5th. A TURNSTILE which conſiſts of two or three pieces of timber framed croſswiſe, making four or ſix rays like the ſpokes of a wheel; this frame is put on a poſt in the middle of a paſſage to turn horizontally, ſo that two of its rays always ſtretch acroſs the paſſage, and prevent more than one perſon at a time from paſſing the ſame way.

6th. A HERRISON, which is a cheveaux de frize turning horizontally on a poſt in the middle of a paſſage like a turnſtile.

7th. KLINKETS, are ſtrong doors or gates made like paliſades, and are hung and faſtened as other gates are.

63. *Of Redouts.*

A REDOUT is uſually a temporary work, thrown up to ſtrengthen the lines which ſhut up, or ſecure a *paſs*: They are uſually figures of three, four, five or ſix ſides, encompaſſed with a ditch and a bank of earth.

The bank encompaſſing ſuch works generally conſiſts of two parts, called *rampart* and *parapet*.

64. The RAMPART is a large bank ſurrounding a work or place, of a height ſufficient to cover the habitable parts of the houſes (if any) from the direct fire of the enemy; or to raiſe the defendants ſo, as to command the neighbourhood; and of a thickneſs ſufficient to reſiſt the efforts of an enemy's cannon for ſome time.

65. The PARAPET, or breaſt-work, is a bank raiſed on the rampart cloſe to its outer edge, to cover and defend the troops poſted behind it, on the rampart.

66. On thoſe ſides of the work likely to be attacked, the parapet is cut into embraſures and merlons, of the ſame ſize and ſhape as has been ſhewn at arts. 35, 46.

Againſt every merlon, a *foot-bank* is raiſed on the inſide for the muſketry to ſtand on when they are to fire over the crown of the parapet.

To every embraſure a platform is to be fitted, either of planks, as ſhewn in art. 36, or of ſtone, as deſcribed in art. 43.

When theſe redouts are intended to defend lines or intrenchments, their faces or fronts ſhould be ſo placed, that the ſhot diſcharged from them may fly directly to the front of thoſe lines; for hereby the enemy may be ſo galled in flank as to find it neceſſary to attack the redouts, and thereby either weaken his attack on the lines, or cauſe him to loſe time: But when redouts are built more particularly to defend the ſpot whereon they ſtand, their faces muſt then front the places from whence they may be battered, and alſo command the ways by which they may be approached.

67. The inner ſides of ſquare redouts are uſually between the limits of 12 yards and 32 yards; and when they are to be defended by muſketry, the number of men neceſſary to the defence may be thus determined.

RULE. *Half the ſide ſquared gives the number of troops.*

EXAM. In a ſquare redout, one of whoſe ſides within is 24 yards: Required the number of troops neceſſary for its defence?

Half of 24 is 12: Then the ſquare of 12 is 144 for the number of men.

AND, Twice the ſquare root of a given number of men, ſhews the length in yards of the ſide of a ſquare redout proper to contain them.

Thus to contain 100 men, whoſe ſquare root is 10, the ſide of the ſquare redout muſt be 20 yards.

68. *To conſtruct a Square redout.* Plate XII. Fig. 23.

1ſt. Mark out a ſquare whoſe ſide is adapted to the number of troops that may be allotted for the defence; as AB for the inſide of the rampart.

2d. About this ſquare, at the diſtance of 10 or 12 feet, deſcribe another ſquare, whoſe ſide CD is the inner boundary of the parapet.

3d. Make a parapet of about 9 or 10 feet thick, whoſe outline is the line EF; leave a berm of about 3 or 4 feet broad, whoſe ſide is GH, and dig a ditch of about 16 feet wide, and about 6 or 7 feet deep, which let be rounded before the angles of the redout.

4th. Make the rampart from 4 feet to 9 or 10 feet high, according to circumſtances, let the parapet be 6 or 7 feet higher, and let the foot-bank be 4½ feet lower than the crown of the parapet.

5th. On that ſide moſt ſecure from the enemy make a bridge acroſs the ditch, and a paſſage thro' the rampart: The breadth of this way ſhould be about 4 or 5 feet, if the defence is to be muſketry only; but 9 or 10 feet if cannon are to be uſed; and in either caſe the paſſage is to be ſhut up by a ſtrong gate.

But if the redout is to be defended by cannon, both the rampart and parapet ſhould be at leaſt 5 or 6 feet thicker.

69. As it is cuſtomary for troops to preſent their breaſts to the parapet, and then fire direct before them, there will be a very conſiderable ſpace before each angle of the work, that will be in a great meaſure exempt from the ſhot: To remedy this defect in theſe works, it has been propoſed to round the inſide of the angles of the parapet, and poſt three or four men there to defend the angle, for more cannot well be applied: But this appearing alſo defective, Mr. Clairac has ſhewn an ingenious method to make the fire pretty near equal in all parts; which is done by cutting the inſide of the parapet into notches, whoſe two ſides, of a yard each, are at right angles to one another, and make half right angles with the ſides of the work; the manner whereof, and its defence, will be plain from ſeeing the figure 23, where the lines with dots at the ends repreſent the fire three different ways from the ſame ſide.

There are in many Treatiſes of Fortification directions to make a kind of temporary works called SCONCES, or FIELD-FORTS; ſome whereof, which are pretty well contrived for defence, will be here explained; but one ſpecies of ſconces, called STAR-FORTS, are ſuch *wretched baubles*, that nothing more will be mentioned of them here, than to recommend their plans as pretty things to ſtick on childrens kites.

70. *To conſtruct a Flanked redout.* Plate XII. Figs. 24, 25, 26.

Having deſcribed the inner figure, where AB is an inner ſide of the redout, ſuppoſe of about 18 yards.

Parallel to this figure, at the diſtance of about four or five yards from it (or more if neceſſary), deſcribe an outward figure, whoſe ſides are ED, EF, &c.

Divide each ſide, as ED, EF, &c. into three equal parts, one whereof is EI, FL, &c.; and in theſe ſides prolonged, take DG, EH, &c. each equal to one of thoſe three parts.

From the points G, H, &c. thus found, draw the lines of defence to the angles of the outward figure, as HD, &c.

From the points I, L, &c. draw the flanks IK, LM, &c. perpendicular to the ſides ED, EF, &c. meeting the lines of defence in K, M, &c.

Or, *The flanks may be thus drawn.*

In the line DI continued towards E, take IP equal to twice IE. And from P, as a centre with the radius PI, cut the line of defence in K, and draw the flank IK.

Then to each face (HK), flank (KI) and curtin (IG), make a parapet of about 7 feet thick (or more if neceſſary), which is expreſſed in the plan by drawing lines at that diſtance on the inſide of the ſeveral parts.

Leave a proper berm of about 4 or 5 feet broad, and make a ditch of about 5 or 6 yards wide, whoſe outer line or counterſcarp is to be parallel to the faces and curtins only.

A redout thus conſtructed is more capable of defence than one without flanks: For the curtin IG is well defended by the flank IK; and the face HK has ſome defence from the part DG.

71. *Of Redans.*

A REDAN is a fortified line, broke into ſeveral curtins and flanks; the defences of the flanks being all directed towards one way.

This is a very good work for the defence of any paſſage; ſuch as a hollow way, a road, a river, or a harbour's entrance.

If the defence is chiefly intended for cannon, the diſtance of the flanks from one another ſhould not exceed 300 yards, that being about the point-blank flight of a muſket ſhot: But if the defence is chiefly intended for muſketry, the diſtance of the flanks may be about 50 yards or leſs. In general, the diſtance of the flanks ſhould be regulated according to the number of them intended to be placed within the length of the line. The length of each flank ſhould be about 15 or 18 feet, in order to admit one gun; but if more cannon than one are to be put in a flank, then the flanks muſt be made proportionally longer.

And if the flanks are made about two or three feet lower than the curtins, there will then be no danger of the troops, poſted in the ſaliant angle of one flank, being hit by thoſe in the entring angle of the flank next behind.

72. *To conſtruct a Redan.*

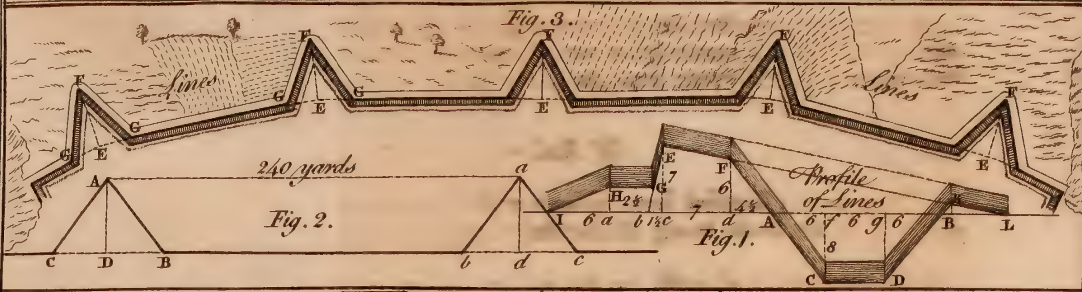
In the front line take the equal ſpaces AB, AB, &c. of the length propoſed for the diſtance of the flanks, as ſuppoſe 50 yards; draw the perpendiculars AC, BD, of 18 feet each, and draw the faces BC, AD.

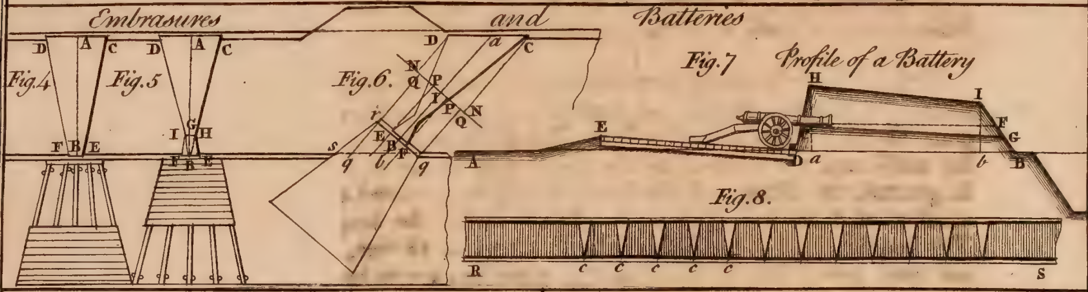
From the ſaliant angles A, B, draw the flanks AE, BF, at right angles to the faces, and the maſter line AEBFAE will be conſtructed.

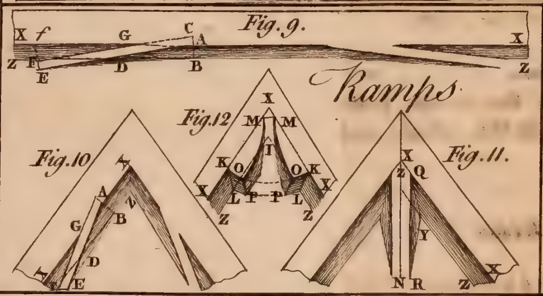
Make a rampart, parapet and foot-bank; ramps in the curtins; an embraſure in each flank, and as many in each face as convenient.

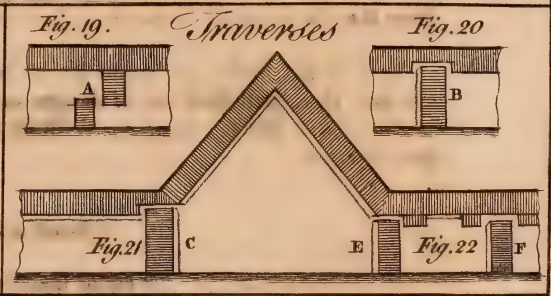
The thickneſs of the parapet, if of earth, may be from 9 to 12 feet; but if of maſonry, about 4 or 5 feet will do.

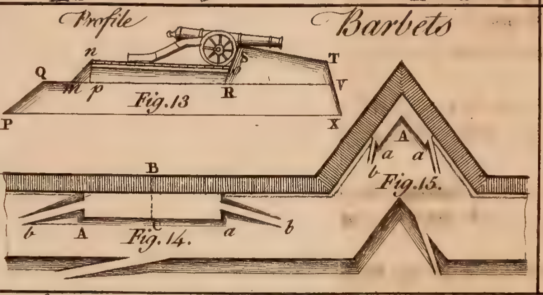
FORTIFICATION . Pl. XII

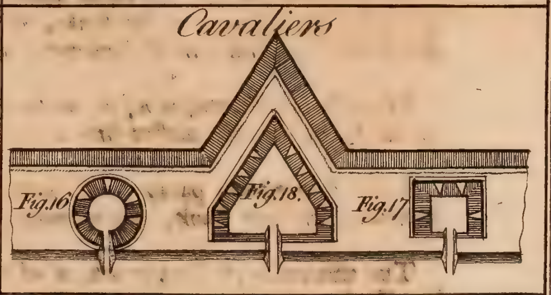


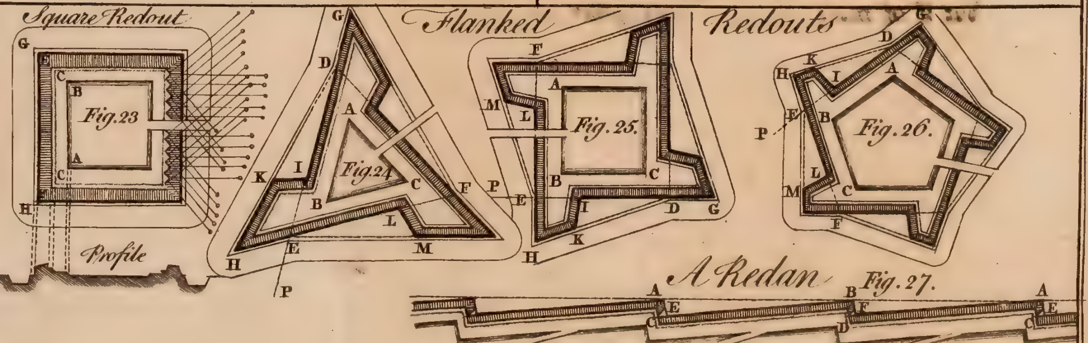












T. Jefferys sculp.

SECTION IV.

Of the Fortifying of Towns.

Towns are fortified by ſurrounding them with a rampart, moat and outworks.

73. The RAMPART of a town is a large bank of earth ſurrounding the place, of a height ſufficient to cover the habitable parts of the houſes from the direct fire of an enemy; and of a thickneſs ſufficient to reſiſt the efforts of his cannon for many days.

The rampart ſhould at certain diſtances, within the reach of muſket ſhot, have works projecting outwards, either contiguous to the rampart, or detached from it; and theſe projections are to be ſo contrived, as to flank or defend one another.

Projecting works contiguous to the rampart are called *baſtions*, and thoſe detached from it, are called *outworks*.

74. A BASTION is a projecting work conſiſting of four lines; namely, of two FACES forming a ſaliant angle; and of two FLANKS, which join one to the end of each face, and have their other ends joined to the rampart.

75. The CURTIN is that part of the rampart which lies between two baſtions.

76. The PARAPET is a breaſt-work ranging quite round the faces, flanks and curtins; of a height and ſtrength proper to cover the troops poſted on the rampart.

77. The MOAT is a large ditch dug on the outſide of the rampart and ſome outworks, quite round the place: The earth that comes out of it ſerves to make the ramparts, parapets, and other elevated works.

The SCARPE is that border or wall of the moat next the place, and the COUNTERSCARP is the oppoſite border or wall.

78. The COVER'D WAY is a ſort of paſſage or ſtreet running quite round the moat next the counterſcarp; and is covered on the ſide next the country by a bank or parapet.

79. The GLACIS is a gentle ſlope of earth deſcending from the parapet of the cover'd way towards the country.

The *head of the glacis* is the higheſt part thereof, or the top of the parapet next the cover'd way. This part is ſometimes called the counterſcarp; but the ſoldiery uſually call the cover'd way and glacis together the counterſcarp.

80. The OUTWORKS, or thoſe detached from the rampart, are of various forms and uſes; ſome to cover the principal parts of the rampart, and to retard the enemy's approaches towards the town, and others to ſecure thoſe places, which, if neglected, might be of advantage to the beſiegers.

81. *The names of the principal parts of the Plan of a Fortreſs.* Plate 13.

The figure HFBMN repreſents the plan of a baſtion.

ag	the thickneſs of the rampart.
ad	the breadth of the parapet.
mmm	the moat, ditch or foſs.
aaaa	the cover'd way.
bbbb	the glacis.

82. *Of the principal Lines.*

The line AB repreſents the exterior ſide of the polygon, and LA its radius.

IK	the interior ſide	and LI	its radius.
IA	the capital	CD	the normal.
GH	the curtin	AH	the line of defence.
GI	the demi-gorge, the br$^{\text{dth}}$	HN	the gorge.

The line HF repreſents the flank } of the baſtion.
And BF the face

83. *Of the principal Angles.*

The angle ALB repreſents the angle of the centre.

∠AAB	the angle of the polygon, or ∠ of the gorge.
∠EGH	the angle of the curtin, or ∠ of the flank.
∠GEA	the angle of the ſhoulder.
∠FBM	the angle of the baſtion, or flanked angle.
∠BAH	the diminiſhed angle.
∠ADB	the exterior flanking angle; or the angle of the tenail.
∠EHG	the interior flanking angle.
apa	the angle of the counterſcarp.

84. *The names of the principal parts of the Profile of a Fortreſs.*
Suppoſed to be taken thro' the line PR, Fig. 6.

The line A*a* repreſents the thickneſs of the rampart at its baſe.

AR	the inner ſlope	of the rampart.
BR	the inner height	
BC	the walk	
CD	the ſlope, and DE the top of the foot-bank.	
EF	the inner face or ſlope	of the parapet.
FG	the top or crown	
GH	the outer ſlope or front	
HI	the face of the wall, called the ſcarp.	
IK	the breadth of the moat.	
KL	the outer wall of the moat, or counterſcarp.	
LM	the breadth of the cover'd way.	
MN	the ſlope, and NO the top of the foot-bank.	
OP	the ſlope of the parapet, or inner face of the glacis.	
PQ	the gentle ſlope, and P the head of the glacis.	

Military works of defence ſhould be conformable to the principles which have from time to time been collected and eſtabliſhed as fundamental propoſitions, ſuch are the following.

85. General Principles, *uſually called* Maxims.

I. The plan of every place that is to be fortified, ought firſt to be circumſcribed with one of the moſt convenient polygonal figures that can be fitted to that place, and this polygon to be fortified.

II. The more regular the circumſcribing polygon is, the better.

III. It is a diſadvantage, to be neceſſitated to extend the works about a fortreſs.

IV. Every ſide of the polygon, as much as is poſſible, ſhould be equally fortified; that the enemy may not have it in his choice to attack a part more weak than the reſt.

V. All works ought, as much as is poſſible, to be eaſy to build, hard to deſtroy, and not difficult to be repaired.

VI. The works about a fortreſs ſhould be ſo contrived, as to cover the defendants, diſcover the approaches of the enemy, and adapted to the common weapons of defence.

VII. Each work ſhould be defended from as many as may be, and liable to be attacked from as few places as poſſible.

VIII. Thoſe works made to defend one another ſhould be ſufficiently large to contain the troops and cannon neceſſary for that defence.

IX. Works which are to flank one another, ought not to be at a greater diſtance than the point-blank flight of a muſket ſhot.

X. The works fartheſt diſtant from the body of the place ſhould ever be loweſt, that they may be commanded by thoſe that are nearer.

XI. None of the works ſhould, if it can be helped, be beyond the point-blank reach of the cannon within the town.

XII. Wet ditches are preferable for ſmall places, dry ones for large places.

XIII. Baſtions with large flanks and large gorges are moſt eſteemed.

XIV. The nearer the flanked angle of a baſtion is to a right one, the better.

XV. The faces of baſtions ſhould in length not differ much from 100 yards.

XVI. A curtin ſhould not be much longer than 180 yards, nor much ſhorter than 100 yards.

XVII. The angle of the curtin ſhould be between the limits of 90 and 100 degrees.

XVIII. The point-blank flight of a muſket-ball is about 300 yards, or within the limits of 240 and 360 yards; and that of a battering cannon is about 1200 yards.

XIX. Battering cannon will drive a ball 14 or 15 feet into a bank of common earth at the diſtance of 300 or 400 yards.

From the foregoing maxims, conſtructions have been made for all the regular polygons from four to twelve ſides incluſive; and the quantity of the ſeveral lines and angles have been obtained from trigonometrical operations; the reſults of which are contained in the following table.

86. *A* TABLE *ſhewing the meaſures of the principal lines and angles in all regular Fortreſſes from four to twelve ſides incluſive. Calculated from the exterior ſide, normal and face being taken as known quantities in yards.*

Names of the polygons.	The exterior ſide in yards.	Radius of exterior ſide in yards.	Interior ſide in yards.	Radius of interior ſide in yards	Capital in yards.	Normal in yards.	Curtin in yards.	Flank in yards.	Face in yards.	Line of defence in yards.	Demigorge in yards.	Angle of the centre.	Angle of the polygon.	Angle of the curtin.	Angle of the ſhoulder.	Angle of baſtion, or flanked angle.	Diminſhed angle.	Exterior flanking angle.	Breadth of the foſs, in yards.
Square	360	254.56	231,00	163.34	91,22	45	156,06	40,54	100	265.96	37,48	90° 00′	90 00	97 01	111 03	61 56	14 02	151 56	30 yds.
Pentagon	360	306,24	247,90	210,90	95,34	54	154,22	48,92	100	268,42	46,84	72° 00′	108 00	98 21	115 03	74 36	16 42	146 36	33 yds.
Hexagon	360	360,00	261.26	261,26	98,68	60	152.80	54,54	100	270,28	54,26	60° 00′	120 00	99 13	117 39	83 08	18 26	143 08	36 yds.
Heptagon	360	414,82	272,44	313,96	100,96	64	151,80	58,32	100	271,62	60,32	51° 26′	128 34	99 47	119 21	89 26	19 34	140 52	40 yds.
Octagon	360	470,36	280,06	365.96	101.40	68	150,54	62,12	100	272,86	64,76	45° 00′	135 00	100 21	121 03	93 36	20 42	138 36	40 yds.
Nonagon	360	526,28	285,86	417,86	108,42	72	140,40	65,92	100	274,32	68,2	40° 00′	140 00	100 54	122 42	96 24	21 48	136 24	40 yds.
Decagon	360	582,50	288,52	466,90	115,60	78	147,34	71,66	100	276.46	70,58	36° 00′	144 00	101 43	125 09	97 08	23 26	133 08	42 yds.
Undecagon	360	658.78	292,60	519 36	119,42	82	142,90	73,96	102	276,30	74,84	32° 44′	147 16	102 15	126 45	98 16	24 30	131 00	44 yds.
Dodecagon	360	695,46	308,20	572,14	123,32	86	128.68	76,18	104	276,33	78,76	30° 00′	150 00	102 46	128 18	98 56	25 32	128 56	46 yds.

By the help of this table, every thing relative to the Maſter line of any of theſe Fortreſſes are readily conſtructed.

87. PROBLEM I.

To deſcribe any of the polygons in the table.

First. *To conſtruct a polygon in a circle.* Plate XIII. Fig. 1.

1ſt. With the exterior radius of the given polygon deſcribe a circle.

2d. Apply the exterior ſide equal to 360 yards within the circumference of that circle, from A to B, B to C, C to D, *&c.* as many times as the propoſed polygon has ſides.

3d. Draw the lines AB, BC, CD, *&c.* and the polygon will be conſtructed.

88. Secondly. *To conſtruct a polygon upon the exterior ſide.* Plate XIII. Fig. 2.

1ſt. Draw the exterior ſide AB equal to 360 yards.

2d. At the ends A, B, make angles equal to the angle of the polygon, and in that poſition draw the lines AE, BC, each of the length of AB.

3d. At the points E, C, make angles as before, and in thoſe poſitions draw the lines ED, CD, each of the ſame length as AB.

And thus proceed until the polygon is conſtructed.

Note, The two laſt lines may be found by deſcribing interſecting arcs D, with the radius AB, from the centres E and C.

89. PROBLEM II.

To fortify any regular polygon in the table. Or, To draw the MASTER LINE of a regular fortreſs.

First. *From the exterior ſide.* Plate XIII. Fig. 3.

1ſt. Make the exterior ſide AB equal to 360 yards, and find its middle C.

2d. Draw CD at right angles to AB, and make CD equal to the normal.

3d. Thro' D draw the lines of defence ADH, BDG.

4th. Make the faces AE, BF, each of their proper lengths.

5th. Transfer the diſtance FE from F to G, and from E to H.

6th. Draw the curtin GH, and the flanks EG, FH.

This work being done for every front or ſide, the maſter line of the fortreſs will be deſcribed.

This method is moſt fit, when the maſter line is to be laid down on a place where there were no works before.

90. Secondly. *To fortify from the curtin.* Fig. 3.

1ſt. Make the curtin GH of its proper length, for the given polygon.

2d. Make the angles of the curtin HGE, GHF, as per table.

3d. In the lines GE, HF, take the flanks GE, HF, of their proper length.

4th. Make the angles of the ſhoulders GEA, HFB, as per table.

5th. Make the faces FB, EA, of their proper lengths.

This method is proper to be uſed when a piece of an old fortification is to ſerve for a curtin, to ſave expence.

91. THIRDLY. *To fortify from the interior ſide.* Fig. 3.

1ſt. Make the interior ſide IK of the length given in the table for the propoſed polygon.

2d. From each end ſet off its proper demigorge KH, and GI.

3d. On K and I as centres, with the extent of the capital, as per table, deſcribe arcs at B and A.

4th. On H and G as centres, with the length of the line of defence, as per table, cut the former arcs in A and B.

5th. Draw the lines AH, BG; in which take the faces AE, BF, and draw the flanks EG, FH.

This method is uſeful when modern ramparts and baſtions are to be annexed to ſimple walls ſurrounding a place.

In either of the above methods, the work here deſcribed for one front is to be applied to every front of the polygon; and it is recommended to the learner, that he applies the precepts given for one front, to a compleat polygon; and ſhould a frequent repetition of theſe operations to a whole polygon become diſagreeable, they may be done only on two fronts, which may be thus drawn.

Draw a capital line AL; make the angles LAB, LAA, each equal to half the angle of the polygon; and make the ſides AB, AA, each equal to 360 yards.

92. PROBLEM III.

To conſtruct the plan of a baſtion. Plate XIII. Fig. 4.

1ſt. Draw a capital line BK, and make the angles MBK, FBK, each equal to half the flanked angle.

2d. Take the lines BF, BM, each of the length of the face.

3d. At the points F, M, make the angles of the ſhoulder BFH, BMN.

4th. Make the lines FH, MN, each the length of the flank.

5th. At the points H, N, make the angles FHG, MN*a*, equal to the angle of the curtin, and draw the pieces of the curtin HG, N*a*.

This problem may be found uſeful on many occaſions; particularly when the drawings of works in a baſtion are to be repreſented with that baſtion only, on a large ſcale; therefore it was here introduced, more eſpecially for beginners, who are for the moſt part apt to be ſomewhat puzzled about conſtructing part of a work, independent of the whole.

93. PROBLEM IV.

The maſter line of a fortreſs being given; to draw the plan of the rampart. Plate XIII. Fig. 5.

1ſt. Draw the lines ag perpendicular to each face, flank and curtin.

2d. In each of the lines ag take $ag = 24$ yards, $ab = 20$ yards.
$ac = 8$ yards, $ad = 6$ yards.

3d. Thro' the points d, c, b, g, draw lines parallel to the maſter line; that is, to each face, flank, and curtin, interſecting one another.

Then the breadth of the rampart is repreſented by ag = 24 yards.
of the parapet by ad = 6 yards.
of the foot-bank by dc = 2 yards.
of the walk of the rampart by cb = 12 yards.
And of the ſlope of the rampart by bg = 4 yards.

The breadths of theſe parts of the rampart are ſometimes different, according to the quality of the earth, or other materials the work is to be built with.

Sometimes the baſtions are made ſolid; that is, the rampart fills up the whole ſpace contained within the faces, flanks and neck: The plans of ſuch are repreſented by continuing the pair of lines bg, forming the inner ſlope of the rampart, againſt the adjacent curtins, till they meet the capital in the breaſt of the baſtion, as at R: But then this pair of lines is to be omitted againſt the flanks and faces of ſuch baſtions.

In plans drawn from a large ſcale, it is uſual to expreſs the outſide ſlope of the rampart by a pair of lines; that is, by drawing a parallel to the maſter line at about five or ſix feet diſtant from it on the outſide.

The maſter line is to be drawn the thickeſt; the inſide of the parapet ſomething finer; and the other lines as fine as they can be drawn.

94. Before any of the lines are drawn in ink (for it ſhould be remarked that every thing is firſt to be drawn in black lead pencil), let the ramps be put in the inner ſlope of the rampart (52); the embraſures in the parapets of the flanks (46); the barbets in the ſaliant angles of the baſtions, fig. 6. with their ramps (56); and the cavaliers, if any are to be, in the ſolid baſtions, fig. 7. with their ramps and embraſures (58).

All theſe ſeveral parts being laid down with black lead pencil, let the lines be neatly drawn with Indian ink, taking care not to draw them beyond their proper terminations; for wherever ſuperfluous ink lines are ſcraped off, thoſe plans will never look well when they come to be waſhed with any colour.

When the plan is to be waſhed, that is coloured, either with tints of Indian ink or other colours, leave the lower line of the inner ſlope of the rampart in lead pencil, which will make it appear ſofter when the drawing is cleaned off.

REMARKS.

95. In the middle of baſtions, fig. 8. it is uſual to build magazines for the ſtores of powder, bombs and other fireworks, and alſo to contain the proviſion for the troops: For in theſe places they are not only more out of the way of doing damage to the town on an accident of blowing up, but they are alſo nearer at hand to be tranſported to the ſeveral works where they may be wanted.

Theſe magazines are uſually built about 20 yards long by 12 broad in the clear, and about 8 feet high in the upright, beſides the riſe of the ſemicircular vault: The ſide walls are about 8 or 9 feet thick at the foundations, and about 8 at top; the end walls about 5 at bottom and 4 at top: And that they may be bomb proof, the work is about three feet thick in the *reins*, or juſt above the ſpringing of the arch, and eight or nine feet thick in the crown or top; this is effected by building the roof ſloping on the outſide, like the roof of a houſe.

Theſe buildings are ſometimes ſtrengthened on each ſide by five buttreſſes 6 feet by 4; and in each ſide wall, there ſhould be left in the ſolidity of the wall five vent-holes to air the magazine: Theſe vents wind round a kind of ſhaft of about a foot ſquare. In each gable end, a ſmall window is made to give light.

96. Magazines may be either in hollow or ſolid baſtions; taking care in the latter to leave an area about their walls: And altho' there are thoſe who would have the magazines at the foot of the rampart along the curtins, in order (as they ſay) that the baſtion by being left clear, may be diſputed with the enemy inch by inch at laſt; but as there are very few examples, ſince the modern practice of war, of ſuch extraordinary reſolution in the defendants after a breach is made, therefore the reaſons for having the baſtions thus unincumbered with buildings, are rather ideal than real, and conſequently can have but little weight: However, when the ditch furniſhes earth enough, or it can be otherwiſe eaſily had, it has been the practice of the moſt celebrated engineers to make full baſtions, eſpecially if they were ſmall and had narrow necks.

97. In the ſaliant angles of baſtions, fig. 7. ſuch as the flanked angle, and the angles of the ſhoulders, it is uſual to make little centry-boxes either of wood or ſtone, for the centinels poſted there to ſecure themſelves from the inclemency of the weather and random ſhot: They are furniſhed in their ſides with loopholes, through which may be ſeen what is doing in the ditch and cover'd-way, and alſo to fire through on occaſion.

The plans of theſe centry-boxes may be either ſquare, round, or pentagonal, and their floors are on a level with the walk of the rampart; their communication is by a paſſage of about 3 feet wide, brick'd on each ſide, cut through the parapet.

The centry-boxes built of ſtone, are uſually ornamented with mouldings, and the arms of the prince or ſtate.

98. PROBLEM V.

The maſter line of a fortreſs being given, to draw the plan of the foſs and eſplanade. Plate XIII. Fig. 4.

1ſt, On the flanked angle B of each baſtion, with the radius BC equal to the breadth of the foſs found in the table, deſcribe an arc CC.

2d. Lay a ruler to touch each arc at C, and the angle E of the neareſt ſhoulder of the next baſtion, and in that direction draw the lines C*p*, meeting one another in *p*.

3d. From the flanked angle of each baſtion, draw lines B*q* at right angles to C*p*.

4th. In each of the lines B*q*, take C*a* = 10 yards, (Fig. 4.)
C*o* = 12 yards, and C*q* = 60 yds.

5th. Thro' the points *a*, *o*, *q*, draw lines parallel to C*p*; meeting before the middles of the curtins at C and *t* (Fig. 3.), and before the flanked angles of the baſtions in *v*, *x*, *y*.

Then will BC repreſent the breadth of the foſs.
C*q* of the eſplanade.
C*o* of the cover'd-way.
ao of the foot-bank.
oq of the glacis.

The arcs CC repreſent the roundings of the foſs.
The lines C*p* the counterſcarp.
*x*C the head
xy the ridges
st the vallies
And *yt* the foot
of the glacis.

The head of the glacis is to be drawn ſtrong, and all the other lines are to be fine.

99. When the plan is to be waſhed, if the foot of the glacis be drawn in lead pencil only, the termination of the glacis, or its concourſe with the adjoining lands, will appear more ſoft and neat.

In the colouring of the glacis, it is uſual firſt to lay a very light tint of colour over every plane, and then to ſtrengthen the colour on every ſecond plane, beginning at any ſaliant angle; the ſtrongeſt tint to be next the head of the glacis, and to be waſhed gradually off; ſo that the limits of the lighteſt ſhade ſhall lie in a diagonal line from the foot of the glacis at a ridge, to the head of the valley, *as from y to s.*

Give a light touch of the pencil or bruſh, with a middling tint of Indian ink along the inſide of the line, denoting the foot-bank.

Waſh the borders of the ditch near the ſcarpe and counterſcarp, ſoftning the edge of the colour with a bruſh wet with fair water: In wet ditches the colour uſed is diſtilled verdigreaſe; but in dry ditches uſe biſter.

The parapet is generally coloured with a middling tint of Indian ink.

100. By this method of drawing the counterſcarp, all the foſs is ſeen from the flanks, and conſequently is defended by them, and muſt be more advantageous than if the counterſcarp was directed to any other part of the flank, the intercepted part next the ſhoulder being thereby rendered uſeleſs for the defence of the ditch; nevertheleſs, if it was on any account neceſſary, the direction of the wall of the ditch may point within the ſhoulder by the thickneſs of the parapet of the face, and ſtill the foſs would have the whole defence of the flank.

101. Fortifications in general would be very defective without foſſes; for the wall or rampart need not be raiſed ſo high when there is a ditch, as they muſt be without one, to ſecure the place from ſurprizes by ſcaling, &c. Neither is a low wall ſo much expoſed as a high one is in the modern methods of attack: Beſides, a place is not ſo liable to the attempts of a ſurprize with a foſs as it would be without one; for the enemy, if diſcovered, may eaſily retreat while he is on a level with the country, which he would find ſome difficulty in doing from the bottom of a deep foſs

bounded by walls or banks nearly upright: Add to theſe, that the earth taken out of the ditch ſerves to make the ramparts, parapets, glacis, &c.

102. It may appear to ſome perſons, that the broader and deeper a foſs is, the better, as it would throw more difficulties in the way of the beſiegers when they wanted to paſs it: But it muſt be obſerved that ſome advantages are beſt waved, when by taking them, greater diſadvantages would enſue. For beſide the great expence that the digging and removing of ſo much earth would occaſion, the enemy might ſee the foot of the wall at a greater diſtance in a broad ditch; and in a deep one, the cannon of the flanks could not dip low enough to defend the bottom. And on the whole, if the foſs by its magnitude furniſhed more earth than was wanted, ſome inconvenience might ariſe in the diſpoſing of the overplus.

103. Thoſe foſſes are beſt which can be filled with water and drained at pleaſure by the help of ſluices or flood-gates; becauſe all the advantages that may be reaped either from a wet or dry foſs, are by theſe means obtained: But as theſe cannot be had every where, the ditch muſt be adapted to the ſituation of the place.

In dry foſſes, a row of paliſades is ſometimes planted along the middle, either upright, or ſloping towards the counterſcarp 20° or 30° from the upright.

In ſome dry foſſes, where water can be had, a trench called CUVETTE *nn* (Fig. 12.) is dug along the middle, of about 15 feet wide and 9 feet deep, for the water to run in.

The breadth of the foſs, altho' unequal in itſelf, is reckoned from the flanked angles, before which it is always rounded; the depth here may be from 15 to 20 feet, and thence riſe gradually to the middle of the curtin, where the depth is 4 or 5 feet leſs.

Of Gates.

104. A GATE in a fortified place, is a paſſage thro' the rampart, which can be ſhut up or opened by the means of *doors* and a *portcullis*.

105. A PORTCULLIS, is either a HERSE conſiſting of ſtrong pieces of timber framed like a lattice, the lower ends of the upright pieces being ſhod with pointed iron, and the whole frame let down by chains or ropes: Or ORGUES, conſiſting of ſeveral long pieces of timber not framed together; each hanging by its particular rope or chain, whoſe ends are wound round a windlaſs which lets them all down together.

The uſe of a portcullis is to ſtop the gateway in caſe of a ſurprize; and in this, the orgues are by much the beſt contrivance; for a herſe may be broke to pieces by a *petard*, or by cannon ſhot: But ſhould a beam in the orgues be ſtruck off in the middle, the upper part will deſcend to ſupply the place of the part taken away.

Gates are either public or private.

106. PRIVATE or POSTERN GATES, are thoſe paſſages thro' the rampart by which the troops can go out of the town unſeen by the enemy, when they paſs to and from the relief of the duty in the outworks; or on any other occaſion which is to be concealed from the beſiegers.

107. Public gates, are thoſe paſſages thro' the middles of ſuch curtins to which the great roads or public ways lead.

They are put in the middles of curtins, as being the beſt defended place in the outline of the rampart.

The dimenſions of a public gateway are uſually about 13 or 14 feet high, and 9 or 10 feet wide, continued thro' the rampart, with proper receſſes for the foot paſſengers to ſtand in while the wheel carriages paſs on. It is uſual to ornament the front of the gateway on the outſide with architecture either of the Tuſcan or Doric order, and to cover the paſſage with a ſtrong vault: Over the vault, cloſe to the town wall, is erected a building of about 18 or 20 feet ſquare, in which is ſuſpended the portcullis; and on the inſide of the rampart there is generally raiſed another building, of about 100 feet front and 30 deep, and high enough to contain one or two floors of rooms for one of the town-officers, the ground floor ſerving for guard-rooms for the troops who are on duty at the gates.

108. *To conſtruct the Plan of a gate with the adjoining buildings.* Pl. XIII. Fig. 9.

Let the line ac repreſent the thickneſs of the baſe of the rampart, and the middle line of the gateway; in which take theſe meaſures in feet: $af = 4\frac{1}{2}$; $fr = 6$; $rh = 18$; $ci = 30$; and $cm = 15$: Thro' theſe point lines being drawn parallel to the curtin, take $fd = 4\frac{1}{2}$; $fb = 14$; $rg = 9$; $ck = 100$; and $kl = 6$ feet, and complete the figure.

Then bg repreſents the plan of the frontiſpiece; gh of the portcullis room; ik of the arcade or guard-houſe; and lk is the breadth of the ſtairs to aſcend the rampart.

The plan to which theſe directions refer is on the right hand ſide of the plate.

109. *Of the diſpoſition of the Streets and Buildings in a Fortreſs.*

When a new town is built and fortified, and all that relates to the rampart is fixed with regard to ſituation and ſize; then the plan of the ſtreets are to be conſidered; and herein, ſome authors have thought it convenient to adapt the poſition of the ſtreets to the climate the town is built in.

Thus in hot climates, they would have the ſtreets run NE. and SW.; NW. and SE.; for then the ſtreets will be ſhaded by the houſes from the mid-day ſun: In this manner *New Briſac*, part of *Malta*, and ſome other regular built towns are laid out. But in cold climates, they adviſe to place the ſtreets ſo as to run north and ſouth, eaſt and weſt, in order to have as much ſun heat as can be.

110. *To deſign a Plan of the ſtreets and buildings.*

About the middle L of the town, deſcribe a ſquare, whoſe ſides ſhall be parallel to the poſition of the ſtreets (already determined); this ſquare is called the great place of arms, whoſe ſize ſhould be proportioned to that of the town, and to the number of troops deſigned for its defence. Thus in a ſquare, make the ſide of the place of arms about 90 yards; in a pentagon, about 100; a hexagon, 120; a heptagon, 140; an octagon, about 160 yards, &c. In this place of arms the troops parade, or are aſſembled for their daily exerciſe.

In the continuation of each ſide of the ſquare, draw ſtreets of about 10 yards wide; likewiſe thro' the middle of each ſide draw a ſtreet of about 12 yards broad; croſs theſe ſtreets perpendicularly with others of about 8 yards wide; make the parallel diſtance of theſe croſs ſtreets about 40 yards, and continue all the lines to the rampart.

It is not neceſſary that the middle ſtreets going from the great place of arms L ſhould terminate directly againſt the gate E, fig. 9. But it is ſomewhat more convenient, when the circumſtances of the place will admit it to be ſo.

Make ſtreets of about 10 or 12 yards wide, parallel to the curtins, and bounded on one ſide by the rampart: About 15 yards diſtant from this ſtreet, within, draw another ſtreet of about 9 yards wide: In the ſpace H between theſe two ſtreets, the barracks for lodging the officers and ſoldiers are built; and in the ſtreet next the rampart, the piles of ſhot and bombs are ſometimes placed.

The length of the plan of a barrack before a curtin is about 140 or 180 yards, and the plan of a pavilion I for the officers may be about 25 yards long by 20 yards broad.

Againſt thoſe curtins where the public gates E are placed, the barracks are diſcontinued for about 40 yards on each ſide the gate, making thereby an area of about 80 yards long and about 36 broad, ſerving for a leſſer place of arms where the guards of a gate may draw up, in caſe of a ſurprize: Moreover, this area is uſeful for the carriages that are going out to ſtop in, until thoſe on the bridge coming in have entered the gate. In figures of 4, 5, or 6 ſides, this area is leſs.

The extremities I of the barracks next the gates and baſtions are uſually aſſigned for the officers pavilions, being the moſt airy places.

III. Of the rectangular plats made by the interſections of the ſtreets, the moſt conveniently ſituated ones are to be choſe for the public buildings; ſuch as the arſenal, church, town-houſe, market, governor, and for the other chief officers in the ſervice of the ſtate; and on the remaining plats, houſes are built for the burghers.

Beſide the guard-houſes of the gates, there ſhould be others made on the ramparts for the centinels appointed for the night watch; theſe guard-chambers are often placed at the centers of the necks of baſtions, when in thoſe places there are no cavaliers or magazines of powder: They are alſo well diſpoſed, when ſet on the middles of thoſe curtins where there are no public gates, eſpecially when there is a water-gate thro' which runs a canal or river.

The arſenal ſhould be erected in a place the leaſt liable to accidents of fire; and if there is a conveniency of water carriage in the town, the arſenal ſhould be placed as near the water as may be.

There are no general rules to be given for fixing the places on which the public buildings are to be erected, becauſe the circumſtances by which engineers regulate their plans are various: Therefore in the figure referred to, which is a regular pentagon fortified in the common way, the ſtreets and buildings are laid out in imitation of their diſpoſition in *New Briſac*; which being in general eſteem, is uſually propoſed as a pattern for beginners.

There are many writers on this ſubject, who propoſe to make the great place of arms or parade, ſimilar to the figure of the town when regular; and from the angles and ſides of this parade, draw ſtreets to the middle of the baſtions and curtins: But as this diſpoſition ſpoils moſt of the corner houſes in the town, by making the walls at oblique angles to one another, it was thought ſufficient to have barely mentioned ſuch conſtructions.

Of Bridges.

112. The paſſage over the moats of fortified places is by bridges, moſt commonly made of timber, and ſupported by frames riſing from the bottom of the ditch: Such bridges are either *private* or *public.*

PRIVATE BRIDGES ſerve for the eaſy communication between the outworks.

PUBLIC BRIDGES, are thoſe by which carriages and paſſengers go over when they come into or depart from the town; and ſuch bridges conſiſt of two parts, namely, the *fixed* and *moveable.*

The FIXED or DORMANT parts of a bridge, are thoſe parts which are ſtrongly joined to the ſupporting piers; and are never moved but in the caſes of repairs, or the danger of a ſiege or ſurprize.

The MOVEABLE or DRAW-BRIDGE, is a floor of timber framed together, one end of which ſerves as an axis, whereby the other end may be drawn up or let down by ſome eaſy contrivance: The moſt common way is by a kind of balance called *plyers.*

The PLYERS are two timber leavers about twice the length of the bridge they lift, and joined together by other timbers framed in the form of a St. Andrew's croſs, which ſerves as a counterpoiſe. The plyers are ſupported by two upright jaumbs, on which they ſwing; and the draw-bridge is raiſed or let down by the means of chains joining the ends of the plyers and bridge.

The breadth of a public bridge is uſually about 16 feet, including the rails and footway of about 3 feet on each ſide: But the breadth of the draw-bridge is only 9 or 10 feet, and its length about 15 feet.

The draw-bridge is generally placed cloſe to the gate, whether it be the gate of the town or that of an outwork; and is then by the means of the plyers drawn up againſt the gate: But when a bridge is more than 40 yards long, it is uſual to put, beſides the draw-bridge at the gate, another about the middle of the bridge.

113. *To draw a bridge in the Plan of a Fortreſs.*

Before the gates draw four lines acroſs the ditch, making three intervals or ſpaces, the middle one being 10 feet broad, and the ſpace on each ſide three feet.

Divide the length of the bridge into parts of about 16 feet long each, to expreſs the diſtance between pier and pier, or the bays of building, and againſt each diviſion, on the outſide of the lines, make a ſquare of a foot, to expreſs the ends of the piers ſupporting the bridge.

Allow the bay next the gate for a draw-bridge; and if the length of the bridge exceeds 40 yards, allow the middle bay for another draw-bridge: Theſe are to be diſtinguiſhed by drawing two diagonals acroſs the middle interval of theſe bays; that of the other bays having lines drawn acroſs them at a foot's diſtance from one another, and the ſpace on each ſide left white for the footway; which are to be broke off at each draw-bridge. See figs. 13, 15.

114. *Of the Orillon and Retired flank.*

When the beſiegers of a fortreſs have made a breach in the face of a baſtion ſufficiently perfect, and have every thing ready for the ſtorm, they then croſs the ditch to the attack, if the beſieged will ſuffer it to be brought on: In this attack, the fire from the flanks is the moſt effectual defence; and cannon placed there, loaded with grape or caſe ſhot, would then do great execution: But of this the beſiegers are well aware, and therefore take care beforehand to diſmount all the cannon flanking their intended paſſage of the foſs; and as this cannot be well prevented by the beſieged, eſpecially when the flanks are plain ones, ſeveral of the moſt eminent engineers have propoſed, and actually built part of the flanks retired behind the ordinary limits, leaving at the ſhoulder of the baſtion a maſs of earth, commonly called an Orillon, which is to ſerve as a ſkreen between the enemy's direct fire and a part of the flank. In this covered part are reſerved one or two cannon, to be uſed only in the defence of the breach in the face of the next baſtion.

This notion of covering part of the flank, is almoſt as old as the modern method of fortification.

115. *To conſtruct the Orillon and Retired flank.* Plate XIII. Fig. 10.

1ſt. At right angles to the face AS, draw from the angle of the ſhoulder the line S*b* equal to 8 or 9 yards, and make *b* the centre of the arc, S*a* forming the *orillon.*

2d. From a point *z* in the face of the next baſtion, fig. 6, about 15 yards from the point A, draw thro' *a* a line *zm*; in which, and alſo in the line of defence A*r* produced, take the *briſures* or *breaks am* and *rn*, each 10 yards.

3d. From *m* and *n*, with the radius *mn*, deſcribe arcs cutting in *d*, which make the centre of the arc *mn*, or *concave flank.*

4th. In *dm* produced lay the ſeveral breadths of the parts of the rampart; as the parapet = 6 yards, foot-bank = 2 yards, walk 12 yards, and the ſlope = 4 yards; then from the centre *d*, thro' thoſe points deſcribe arcs, meeting in the continuation of the correſponding lines from the face of the next baſtion.

The parapet of the orillon is drawn parallel to *s a* at 6 yards diſtance.

The axis or middle line of each embraſure ſhould tend towards a point about the middle of the foſs oppoſite the flanked angle of the next baſtion.

The wall in the upper briſure *a m*, as it cannot be battered, need not be above 2 or 3 feet thick to ſupport the earth behind it.

Thro' this wall there ſhould be a ſally port coming out at the bottom of the foſs if a dry one, or a little above the water line in a wet foſs: The deſcent to this port is by a paſſage under the rampart of the flank; but in ſtrait flanks, the ſally port is in the curtin next the angle of the flank, the paſſage to it being under the rampart of the curtin.

116. *Of Double flanks.*

As the progreſs of the works of the beſiegers generally depend on their having a greater army than is in the town beſieged, and of forming a greater fire on the town than they can return; therefore ſome engineers have endeavoured to hinder the progreſs of the beſiegers batteries, by furniſhing the town with an equivalent, or rather a ſuperior fire; and this has been propoſed to be effected, by making ſecond and third flanks one behind another, gradually more elevated than thoſe before: For as it is found convenient to ſilence the fire of the flanks, before the beſiegers can avail themſelves of the breach they make in the face of the baſtion; therefore batteries to ruin the flanks are made, and play at the ſame times as thoſe for the breaches in the faces. Now the batteries for the ruin of the flanks, can be conveniently made only within about 10 yards of the head of the glacis, and their length not greater than about 40 yards, containing at moſt about 6 or 7 cannon: But if the beſieged can by any artifice preſerve the cannon in the oppoſite flank, and have a greater number there than are in the battery oppoſed, conſequently their fire will be ſuperior, and ruin the battery intended to offend them; and this was expected to be accompliſhed by *double*, or *cazemated flanks*.

In ſome places two or three tier of cannon were placed one above the other, the upper ones being ſupported by vaulted work, as in the Tower of London; but ſuch having been found very inconvenient, on account of the great ſmother contained in the vaults, they have been generally conſtructed open.

The cazemated flanks have been condemned by many writers, becauſe they may be rendered uſeleſs by the enemy's bombs; was this objection juſt, it would hold againſt any ſmall work; for the beſiegers having once got the length to any place, they may be ſuppoſed to render that place alſo uſeleſs to the beſieged; and it would thence follow, that it were beſt not to have any places of defence: But as the utility of ſuch works have been commended by ſome of the moſt eminent engineers, it was judged proper here to mention how theſe flanks may be conſtructed.

SECTION V.

117. *Of Works for the defence of the Foſs.*

Such works are uſually called *tenails*, or *ramſhorns*, or *caponiers.*

A **Tenail** is a work raiſed in the ditch before the curtin upon the lines of defence.

A **Ramshorn** is a curved tenail raiſed in the foſs before the flanks, and preſenting its convexity to the covered way.

A **Caponiere** is a kind of covered way acroſs a dry ditch before the middle of the curtin; and limited between the lines of defence and the counterſcarp.

The *tenails* never riſe above the common ground level, but are frequently two or three feet lower: They conſiſt of a rampart about 36 yards thick, covered by a parapet of cannon proof, with one or two foot-banks. Theſe works are placed at ſuch a diſtance from the curtins and flanks, that the ſplinters of ſtone knocked off them by the beſiegers cannon may not hurt the troops poſted there to flank the enemy in their paſſage of the foſs; and this is their principal uſe.

The *caponiere* is of like uſe, but is uſually ſunk about two or three feet lower than the bottom of the foſs: It is about two or three yards broad, and is covered by a parapet about ſix feet high on each ſide, which ſlopes away like a glacis about 15 yards broad. It is frequently covered by a roof made with hurdles, to ſuſtain a floor of earth about a foot thick, and the whole ſupported with thick planks of muſket proof, leaving convenient loop-holes for the defendants to fire through.

118. *To conſtruct Tenails.* Plate XIII

Firſt ſort with flanks, Fig. 11. Parallel to the curtins and flanks, draw the lines *eg* at 6 yards diſtance, and E*e*, G*g*, at 10 yards diſtance: From F, and D, the middles of CG, CE, draw the flanks F*f*, D*d*, at right angles to the lines of defence A*g*, B*e*; draw the curtin *df*, and put in the rampart, parapet, and foot-bank.

Second ſort, with faces only, Fig. 12. Take the diſtances from the curtin and flanks, the ſame as before; and to the lines of defence annex the rampart and parapet.

Third ſort, with faces and curtin, Fig. 3. When the lines of defence croſs one another in D, ſo near the curtin that there is not room for the thickneſs of the rampart and its diſtance from the curtin, make the faces *ab*, *cd*, each of $\frac{2}{3}$ of *a*D, and draw the curtin *db*.

119. *To conſtruct a Caponicre.* Fig. 12.

From the exterior flanking angle D, draw a line D*p* to the angle of the counterſcarp *p*; on each ſide of D*p* draw parallel lines, at the diſtances of $1\frac{1}{2}$, $2\frac{1}{2}$, and 15 yards from D*p*; theſe lines being limited by the lines of defence and counterſcarp, form the caponiere.

This work, which can be uſed only in a dry ditch, ſerves, beſides its defence of the foſs, for a convenient paſſage between the town and its outworks; and in this caſe there is uſually a circular excavation made in the angle of the counterſcarp, out of which the troops may defile without being ſeen by the enemy.

120. *To conſtruct a Ramſhorn.* Plate XIII. Fig. 13.

A line D *a* drawn from D the angle of the ſhoulder, at right angles to the line of defence, its interſection *a* with BI, the other line of defence continued, gives the centre *a*; from which, with the radius *a* D, deſcribe the outline AC of the ramſhorn, CD being equal to 10 yards; and annex a parapet, foot-bank, and walk, as in the other tenailles.

This work ſeems preferable to either of the other tenailles, both on account of its ſimplicity, and the defence for which it is conſtructed.

SECTION VI.

Of Outworks.

121. OUTWORKS are all thoſe works advanced beyond the foſs, ſerving to augment the defence of the town, to cover the gates, bridges, and other weak parts; to incloſe thoſe eminences, not too far diſtant, which command the town; to ſurround and defend the ſuburbs, if any; and in fine, to throw ſo many difficulties in the way of the beſiegers, that by the length of the ſiege, the enemy may waſte both his time and troops; beſides, ſuch protraction frequently affords an opportunity of obliging him to raiſe the ſiege, either by the approach of a relieving army, or by the ſetting in of a ſeaſon unfit for military buſineſs.

The outworks recorded by engineers are various, ſuch as *ravelins*, *half-moons*, *lunets*, *countergards*, *horn-works*, *crown-works*, *tenails*, and ſeveral others: But many of them having been found defective, are now diſuſed in all new works and alterations; and therefore thoſe only which are now in moſt eſteem will be here treated of, referring the more inquiſitive readers to the writings of *Mallet*, *Dedier*, *Le Blond*, *Muller*, and others.

122. The conſtructions of outworks depend on much the ſame principles as thoſe of the place itſelf; to which may be added:

1ſt. Every part of an outwork ought to be flanked or defended either from ſome neighbouring work, or from the town itſelf; whereby the enemy may not find any place of real ſhelter among the outworks, without being at the labour of throwing up a covering himſelf.

2d. As the chief defence depends on the muſket, therefore the parts mutually flanking one another, ought to be within the ordinary reach of that weapon; that is, not exceeding about 300 yards.

3d. Every outwork ought to be commanded from the town; and therefore the more advanced works are ever to be the loweſt. The gradation uſually obſerved from work to work is about three feet; that is, the ramparts of all works advanced before a place gradually diminiſh three feet in height from the rampart of that place: Thus if the town ramparts are 18 feet high, the rampart of the next outwork is 15 feet high, that of the work next advanced is 12 feet, and ſo on; whereby the more advanced outworks are commanded by thoſe next within.

4th. The flanked angle of an outwork ought not to be leſs than 60 degrees.

5th. Each outwork ſhould be ſurrounded with a ditch communicating with the foſs of the town: When all the ditches can be filled with water, they ought to be equally deep; but when that cannot be obtained, the ditches of outworks ſhould be ſhallower than that of the town; whereby the fronts of the outworks will be better defended from the parts which flank them. The breadths of theſe ditches are uſually from about 20 to 24 yards, and rounded at that breadth before the ſaliant angles, with the counterſcarps parallel to the faces or outlines of the work they encompaſs.

6th. The parapets of outworks are to be equally ſtrong and high with thoſe of the town, as they are to be cannon proof, and to cover the troops poſted on the ramparts of thoſe works: So that it is uſual to make the parapets of outworks of about 18 feet thick, 6 or $6\frac{1}{2}$ feet high, with a foot-bank $4\frac{1}{2}$ feet lower than the crown or creſt of the parapet; and the walk of the rampart about ſeven or eight yards broad, with a ſlope within of about once and a half its height.

When the plan of a fortification is to be drawn, in which are outworks, the counterſcarp of the great foſs is to remain in black lead pencil, until the outworks are annexed in pencil alſo, with their foſſes; then the covered way and glacis are to be drawn ſurrounding the foſſes of all the works.

123. *Of the Ravelin.* Plate XIII. Figs. 14, 15, 16, 17.

A Ravelin is a work made before a curtin, ſerving to cover it and the adjoining flanks from the direct fire of an enemy: It is compoſed of two faces, AB, AC (fig. 14), and the two demigorges *p* B, *p* C, taken on the counterſcarp.

To conſtruct a Ravelin. In a line drawn at right angles to the curtin thro' its middle, take the *capital p* A equal to about 100 yards, and draw the faces AB, AC, directed to points in the faces of the next baſtions, about ten yards diſtance from M, the angle of the ſhoulder.

In this work put a rampart of about 16 or 20 yards, and a parapet of about ſix yards; and before the faces put a foſs of about 24 yards wide, rounded before the ſaliant angle A; alſo annex ramps in the ſlope of the rampart, and if proper, conſtruct a barbet in the ſaliant angle.

The gorge of the ravelin, or the part next the town is left open, without any rampart; becauſe the enemy cannot attack it there; and alſo, that it may be entirely commanded from the ramparts of the town.

REMARKS.

124. It is proper to make a ravelin before every curtin, as the flanks are thereby covered from the enemy, and cannot well be ruined before he is maſter of the ravelin; without which, he would have it in his power to batter the flanks from the counterſcarp, both from before the curtin and the face of the baſtion; the latter of theſe being the only place he can do it from, when a ravelin is interpoſed, of which he is not

maſter: But the difficulty of erecting a battery on the head of the glacis againſt the face of a baſtion, is rather too great to be undertaken, while this place is defended by the whole fire of the adjacent face of the ravelin; and therefore the beſiegers can ſcarcely hurt the flanks before they have taken the ravelin; conſequently ſuch works greatly augment the defence of a town.

125. As the face and foſs of a ravelin is defended by part of the face of the oppoſite baſtion; therefore ſhould the faces of the ravelin be directed ſomewhat within the angle of the ſhoulder, at leaſt as much as is the breadth of the parapet and foot-bank of the flank; beſides, by this conſtruction they more effectually cover the flanks, which is one of the principal things wanted, as the flanks are of moſt importance to be preſerved the longeſt.

126. In wet ditches, where the troops paſs from the town to the ravelin in boats, it is proper to make in the gorge of the ravelin, a kind of harbour, where the boats may lie covered from the fire of the enemy; and this may be done various ways: One is, by making an excavation limited by an arc deſcribed from A (fig. 15), the angle of the counterſcarp, with a radius of about 20 yards. In dry foſſes, it is proper to have either ramps or ſtairs in the gorge of the ravelin to preſerve a free communication, ſhould the bridges be broken by the enemy's ſhot.

127. In ſome ravelins (fig. 16) there is conſtructed a kind of *redout*, or KEEP; which is a ſmall work ſimilar to the ravelin, with a ditch of about 10 or 12 yards wide: The capital may be about 30 or 40 yards; and the work covered in the faces by a wall of a foot or two thick, furniſhed with loop-holes for the muſketry to fire through.

This *keep* ſerves to ſecure a retreat for the troops who defend the ravelin, and on this account the defence of the breach in the ravelin may be more obſtinately maintained; and even when the defendants are obliged to give way to a ſuperior force, they may, when retired into the *keep*, prevent the enemy from making a lodgment in the outward part of the ravelin, or at leaſt greatly obſtruct it; and cannot be drove from this place until the enemy has erected a battery, and brought cannon on the ravelin to batter the keep.

The conſtruction may be otherwiſe done, by taking on the gorge of the ravelin the diſtance BA equal to about 20 yards; and out of the reſt form the keep with its foſs; the ſcarp and counterſcarp being drawn parallel to the faces of the ravelin, whoſe two fronts form a work covering the keep, and is uſually called a Countergard.

128. The ravelins, called by ſome authors *half-moons*, have ſometimes their corners at B and C, fig. 14, cut off either parallel to the capital *p* A, or at right angles to the foſs; thereby making a kind of flank of about 12 yards long, with its rampart and parapet, and ſerves to give a more direct fire along the cover'd way, which they are propoſed more particularly to defend: But then this partly lays open the flanks, which the ravelins were originally intended to cover.

129. The celebrated General Coehorn, in the ravelins which he built at *Bergen op zoom*, contrived a very good defence for the covered way before the faces of the baſtions, by making retired flanks in the breaſts of the ravelin, where one or two cannon might be placed as ſecure from

the enemy's fire, as thoſe behind the orillon of a baſtion. Theſe covered cannon in the ravelin ſeem to have been intended for the defence of the covered way on the laſt emergency, like as thoſe in the baſtion were for the defence of the breach when the beſiegers brought on the ſtorm: But the covered cannon in the ravelin ſeem to have this preference; that as towns are not uſually given up until the enemy is maſter of the cover'd way, the ſecreted guns in the ravelin have an opportunity of being employed in the uſe for which they were placed there; whereas the guns covered way by the orillons are very rarely of any uſe, as there are few gariſons which ſtand the ſtorm of the breach in a baſtion.

130. Coehorn's ravelins may be imitated by the following conſtruction. In the gorge of the ravelin take *a b*, fig. 17, equal to about 20 yards, draw the flank *b c* at right angles to *a b*, make *b c* equal to about 12 or 14 yards, and draw the cover *c d* parallel to *a b*: To the flank *b c* annex a rampart, parapet, embraſures and ramp; and to prevent theſe flanks being raked from the enemy's batteries, particularly by the *ricochet*, or bounding ſhot, there may be made a traverſe of about 10 feet thick acroſs the top of the flank at *c*, with a ſmall mine under it, to blow up the traverſe when the beſieged are obliged to quit the ravelin, leſt it ſhould ſerve to cover the aſſailants from the fire of the town.

Coehorn has alſo made flanks at the corners *d* of the ravelin, which may be conſtructed by taking *a n* equal to 10 yards, and drawing *n e* parallel to *b c*, meeting *c d* in *d*; then *d e* is the flank required.

It ſeems proper, when ſuch ravelins are uſed, that the faces ſhould ſpread on thoſe of the adjoining baſtions 10 or 12 yards farther from the angle of the ſhoulder, than in ravelins which have no flanks; and this is done at *Bergen op zoom*, where the faces of the ravelins would fall between 20 and 30 yards from the angle of the ſhoulder on the faces of the baſtions.

131. *Of the Countergard.*

A COUNTERGARD is a work generally ſerving to cover the faces of a baſtion: It is compoſed of two faces, forming a ſaliant angle before the flanked angle of a baſtion.

To conſtruct it. Plate XIII. Fig. 18.

Having deſcribed the ravelins and drawn their foſſes; then in the counterſcarp of the ravelin take *a b* equal to about 24 yards, and draw the face *b c* parallel to the counterſcarp of the foſs before the baſtion; and the outline of the countergard will be determined; the inner boundary being the counterſcarp of the grand foſs.

In this work put a rampart of about 16 or 18 yards broad, with a parapet of ſix yards, and annex the ramps and a barbet if neceſſary: Alſo make a foſs of 24 yards broad, the counterſcarp being parallel to the faces.

The countergard ſeems to be, next to the ravelin, one of the moſt uſeful outworks; for it occupies but little ground, is of no great expence, covers the faces of the baſtion ſo effectually, that they cannot be battered in breach until the enemy has made himſelf maſter of this work;

and when he has it, he will meet with difficulties enough in finding earth to cover himſelf and erect his batteries; and muſt therefore be at a conſiderable trouble in bringing it from beyond the foſs, while he is expoſed to the fire of the faces of the neighbouring ravelins; which, with the flanks of the baſtions, are the defences of the countergard.

132. *Of the Tenaillon.*

A TENAILLON is a work compoſed of a ravelin and two detached works called *lunettes*, which either partly or wholly cover the faces of the ravelin from an enemy's direct fire.

When the detached works cover only the lower part of the faces of the ravelin, they are called *ſmall lunettes:* But when they cover the whole faces, they are called *great lunettes*, and this is the work which is here meant by the word *tenaillon*.

133. *To conſtruct a Tenaillon.* Plate XIII. Fig. 19.

Having deſcribed the ravelin and its foſs, whoſe counterſcarp is rt; then in the face ef continued, take tv equal to about 60 yards, and on the counterſcarp of the grand foſs take rs equal to 25 or 30 yards; then drawing sv, the figure $rsvt$ is the *great lunette*; to which a rampart, parapet, and ramps are to be annexed againſt its faces tv, and branches vs, of the ſame kind with thoſe in the ravelin.

134. A great lunette may be conſiderably ſtrengthened by making acroſs its middle, at A, a retrenchment, conſiſting of a rampart, parapet, and a foſs of about ſix or eight yards broad, and ſeven or eight feet deep; the parapet being drawn at right angles to the counterſcarp of the ravelin againſt the middle of its face; and the ditch of the retrenchment communicating with that of the ravelin.

A *tenaillon* is a work capable of affording a great defence to the beſieged, as was evident at the ſiege of Liſle in 1708, where the beſiegers were twice or thrice drove out of a tenaillon they had taken and retaken.

135. *Of a Horn-work.*

A HORN-WORK is a fortification compoſed of two long ſides, called branches, tending towards the town, and of a front formed by a curtin between two half-baſtions.

This work, when uſed, is ſometimes put before a baſtion, but oftner againſt a curtin.

136. *To conſtruct a Horn-work before a curtin.* Plate XIII. Fig. 20.

In a line drawn from O, the angle of the counterſcarp, at right angles to the curtin, take OC equal to about 250 or 260 yards; thro' C draw AA at right angles to OC, and make CA, CA, each equal to half OC, ſo AA is equal OC.

Take the *normal* CD equal to $\frac{1}{6}$ of AA, thro' D draw the lines of defence AI; make the faces AB equal to $\frac{1}{2}$ AD; transfer the diſtance BB from B to I in the line of defence, draw the flanks BI and curtin II, and draw the branches AQ towards ſome point in the face of the baſtion, about 8 or 10 yards from the angle of the ſhoulder.

Againſt the faces, flanks, curtin and branches, put a rampart and parapet as in the ravelins; make a foſs of 24 yards broad before the flanked angles A, the counterſcarp of the foſs in the front being directed towards B, the angle of the ſhoulder, and the reſt drawn parallel to the branches.

A ſmall ravelin is uſually put before the curtin of a horn-work, for the ſame uſes as that before the curtin of the town: Make the capital CP about 60 yards, draw the faces as in the large ravelins, and make a foſs of about 15 or 16 yards wide, whoſe counterſcarp is parallel to the faces of the ravelin, which are to be furniſhed with a rampart and parapet.

137. Retrenchments are ſometimes made in the horn-work as in the great lunette, and for the ſame reaſon, namely, to increaſe the difficulties of an enemy in a ſiege.

Alſo a ravelin with its foſs is made before the curtin of the town, independant of the horn-work which it commands.

138. There is another work, called a Crown-work, whoſe front conſiſts of a whole baſtion, two half-baſtions, and two curtins, and is bounded on the ſides by two long branches directed towards the town. This work is like two horn-works connected together, by their branches being put ſide to ſide.

Horn-works and *Crown-works* have been chiefly uſed to incloſe ſome riſing or hollow ground, or a ſuburb; but are now in general diſeſteem, on account that their defence is very ſmall in proportion to their coſt, a circumſtance by which all works ſhould be partly rated.

There are ſeveral other works called outworks, which may be found in the treatiſes wrote on Fortification, but are here omitted on account of the intended brevity of this work.

139. *Of the Covered way and Glacis.*

When all the intended outworks are annexed to the plan, and the ſeveral foſſes are drawn, communicating one with another, then the covered way and glacis are to be drawn parallel to the counterſcarps of the foſſes; and a foot-bank is to range quite round the covered way, at the foot of its parapet. The top of this foot-bank ſhould be at leaſt four feet broad, that there may be convenient room left for the troops to ſtand on after the paliſades are planted, a row of them being always to run quite round the covered way. The manner of ſetting them, as recommended by the moſt celebrated engineers, and particularly by the great Marſhal Vauban, the moſt experienced man in military works that ever lived, is to put the paliſades on the upper foot-bank at about a foot diſtant from the foot of the parapet, ſunk in the ground at leaſt three feet, and their top on a level with the head or creſt of the glacis.

Paliſades thus placed are not expoſed to the cannon of the beſiegers; the moſt they can do will be only to bruſh their points: Neither can they be eaſily jumped over by the troops commanded to the attack of the covered way, nor readily cut down; and their diſtance from the parapet leaves a ſpace ſufficient for men to go along to repair any diſorder.

140. *Of Places of Arms.*

Places of arms in the covered way, are ſpaces made at the entring and ſaliant angles, conſiderably larger than the ſtreet of the cover'd way, and formed by turning the head of the glacis into two faces projecting towards the country: Thoſe at the ſaliant angles are formed by the roundings of the counterſcarp; but thoſe at the entring angles are thus conſtructed. Plate XIII. fig. 3.

In the head of the glacis take the gorges co, co, from 20 to 30 yards, draw the faces o *t*, o *t*, ſo that the angles *t* o *a* be between 90 and 100 degrees; and parallel to theſe faces draw a glacis of about 50 yards.

The faces o *t* of the *entring places of arms* ſhould not make angles greater than 100 degrees with the *branches of the covered way* o *a*, becauſe thoſe branches could not then be defended ſo well by the muſketry, as when their ſhot was delivered directly along the glacis nearly parallel to the branches, which can only be done when the defences are nearly at right angles to the places defended.

Some writers have adviſed to round all the ſaliant angles of the places of arms, becauſe thoſe angles could then be defended by more men: But perhaps there might be ſome advantage in notching the faces ſomewhat like a redan, as mentioned at article 69.

141. The great *Coehorn* was ſo conſcious of the advantage of places of arms at the entring angles for the defence of the covered way, that he was very particular in their deſcription, and took ſuch care in the conſtruction of thoſe at *Bergen op zoom*, that they very well anſwered his deſign, as was evident in the famous ſiege of this place in the year 1747.

Coehorn's places of arms may be thus imitated.

Plate XIII. fig. 21. where the work is on a larger ſcale to be plainer.

Take the gorges *a b*, *a b*, about 45 yards, and the faces *b c*, *b c*, about 50 or 60 yards: At 10 yards diſtant from the faces, draw the *firſt lunette* A with a ditch before its faces, both together being about ten or twelve yards broad, its ends being terminated by the line *a b*: Within this lunette, at about 10 yards diſtance, draw a ſecond B of about five yards broad, its ends ſtretching to about half way the breadth of the covered way: Behind the ends of each lunette, at the diſtance of two or three yards, put a traverſe of about five yards thick, reaching from the counterſcarp to about two or three yards farther than the ends of the lunette: And about the angle of the counterſcarp make a ſcreen of about ſix yards in each face and gorge; which ſcreen is of brickwork with loop-holes for the muſketry, to favour the retreat of the defendants when drove from their works in this well-contrived place of arms.

142. *Of Traverſes in the Covered way.*

When the beſiegers have puſhed on their approaches ſo far, as to be within 30 or 40 yards of the head of the glacis, it will be in their power to rake the covered way from ſome of their batteries; to prevent which, and alſo to ſhelter the troops in ſome meaſure from the ricochet or rebounding ſhot, traverſes are thrown acroſs the covered way, particularly on each ſide of every place of arms, and in every branch of the covered way where the length of that branch exceeds 50 or 60 yards.

Each traverſe is furniſhed with a foot-bank, and a row of paliſades planted on the foot-bank; and the paſſage round its end ſhould be furniſhed with klinkets or doors, to ſhut them up when neceſſary.

143. *Of Sally-ways.*

In the middle of ſome faces of the entring places of arms, is made a ſally-way, which is a paſſage cut thro' the parapet, or head of the glacis, for to facilitate the ſallies of the beſieged. To make ſally-ways in the places of arms ſaliant, would be improper; becauſe as thoſe places are the moſt convenient to be firſt attacked, they ſhould not by any means be weakened.

Theſe paſſages are cut oblique to the faces of the places of arms, and wind towards the ſaliant angle in ſuch a manner, as not to be eaſily enfiladed or raked; they riſe gradually from the foot of the parapet, until they meet the ſlope of the glacis at the diſtance of ſeven or eight yards from its head. The roads to the town commonly paſs thro' theſe ſally-ways; every one of which ſhould be furniſhed with a good barrier, to ſhut up againſt ſurprizes and ſudden attacks.

144. *Of Communications.*

Every detached work in a fortification ſhould have a ready and free communication preſerved, otherwiſe they might be diſadvantageous to the place.

Communications are preſerved various ways, otherwiſe than by bridges, which are liable to be deſtroyed by the enemy's cannon. In dry foſſes it is thus:

From the town to the tenaille, by a ſubterraneous way under the rampart in the middle of the curtin into the foſs, and riſe thence by ramps or ſtairs into the tenaille: From the tenaille by a ſubterraneous way into the caponier, and thence to the ravelin either by ramps, ſtairs, or a timber ſtage: From the ravelin to the works beyond, the communication is kept in like manner; or ſometimes a way is ſunk acroſs a ditch, and covered with a parapet next the enemy; and the way from the foſs to the places of arms is alſo by ſtairs, or by a timber ſtage.

Over wet ditches, the troops are conveyed by boats or rafts, or by little bridges about three feet wide lying nearly level with the water's edge; but the latter are inconvenient in the night, and much more ſo when the defendants are obliged to quit the work precipitately.

When wet foſſes are to be repreſented in plans, it is done by giving them a tint with diſtilled verdigreaſe along the borders of their ſcarps and counterſcarps; but in printed plans, it is expreſſed as in the ditch of the ravelin at fig. 15; and dry ditches are ſhewn in coloured plans, by waſhing the ſaid borders with a tint of brown biſter; but in prints, dry foſſes are expreſſed as in the ditch of the ravelin at fig. 14: And a *cuvet* is repreſented by a double line drawn along the middle of the foſs, as againſt the front EB of the polygon.

145. *Of Works beyond the glacis.*

Sometimes, when earth is wanting to raiſe the ſeveral works to their proper height, or when the defence is to be increaſed, a foſs of about 20 or 25 yards broad is ſunk at the foot of the glacis, encompaſſing either the whole or ſome convenient part thereof: But then it is proper that the glacis ſhould ſlope quite to the bottom of this foſs, if it is a dry one, or a wet one which can be drained; for otherwiſe, when the enemy comes to be poſſeſſed of it, he would find a trench ready dug to ſcreen him from the fire of the covered way, and other places.

To this advanced foſs is uſually annexed, when it can be, a covered way and glacis; and there are not wanting fortifications which have three covered ways and glacis's one before the other.

146. Before ſome of the ſaliant angles of the glacis there are ſometimes conſtructed a kind of work called a *lunet*, or by ſome an *arrow*. It conſiſts only of a parapet and foot-bank forming two faces, making a ſaliant angle, whoſe legs are parallel to the head of the glacis, thro' whoſe ridge runs a narrow paſſage to the lunet.

147. Sometimes works called *redouts* are conſtructed before the ſaliant angles; ſome of theſe works have foſſes, covered way and glacis; others are made to depend on their own defence: But to all theſe detached works a proper communication muſt be preſerved with the covered way, and in ſuch a manner as not eaſily to be cut off. When this paſſage is two or three times as long as the glacis is broad, the paſſage ſhould have one or more traverſes acroſs it, to prevent its being raked; alſo, on either ſide, it ſhould be covered by a parapet and ſmall glacis.

148. *Of Profiles.*

The PROFILE of a work is a figure expreſſing the ſeveral heights, depths and breadths of that work.

The profiles of works are regulated according to their uſe, and alſo according to the quality of the materials with which thoſe works are to be made.

Thus the ramparts of the town are ever thicker than thoſe of outworks; the breadth of the parapet only remains nearly the ſame in moſt works: Beſides, a rampart made of good firm earth, need not be ſo thick as one made of looſe and ſandy materials: From 20 to 24 yards will do in the former caſe; but leſs than 25 or 30 yards will not ſuffice with poor earth.

Profiles are alſo regulated with regard to the expence intended to be beſtowed on the works; that is, according to the outſide coating or walling of the rampart and parapet, namely, whether it be done with earth or intire maſonry, or half one and half the other.

149. When a work of earth is raiſed, and the ſurface is covered or plaiſtered with a tenacious ſubſtance made of well-tempered earth or loam; this coating or plaiſtering is called *placcage* or *cruſting*.

And when the ſurface is covered with graſs turf, or, as it is moſt common, with clods of fat mould cut in the form of wedges, and called gazons or ſods: This kind of coating is called *gazonage* or *ſodding*.

150. When the whole front of a work, from the bottom of the foſs to the crown of the parapet, is covered or fronted with a wall of ſtone or brick: This kind of work is called *intire maſonry*.

151. When the front of the rampart, from the bottom of the foſs to the horizontal line, or ground level, or a little higher, is fronted with a wall of brick or ſtone, and the remaining part of the front is coated with earth; then this work is called *half maſonry*.

Conſtruction of Profiles.

152. When the works are coated with earth. Plate XIII. Fig. 22.

Let AHLQ repreſent the horizontal, or ground line, taken thro' the face of a baſtion, and acroſs the foſs, and thro' the cover'd way and glacis: In this line take the following meaſures; namely,

AR = 2 or 3 yards; R*c* = 10 yards; *cd* = 6 feet; *de* = 1½ feet; *eg* = 18 or 20 feet; *ga* = 12 or 14 feet; *a*H = 9 feet; H*l* = 12 feet; *lm* = breadth of foſs; *m*L = 12 feet; LM = 5 yards; M*p* = 7½ feet; *p*Q = 50 yards.

Thro' the points R, *c*, *d*, *e*, *g*, *l*, *m*, M, *p*, draw lines perpendicular to AQ.

In theſe lines take RB = 2 or 3 yards; *c*C = RB + 2 feet; *d*E = *c*C + 1½ feet; *e*F = *d*E + 4½ feet; *g*G = *c*F − 2½ feet; *l*I = 18 feet; *m*K = 18 feet; M*o* = 2 feet; *p*P = 8 feet.

Draw the lines AR, BC, EF, FG, G*a*, HI, KL, L*o*, PQ, Then draw ED parallel to AH, and equal to 3 feet, and draw DC; alſo diſpoſe of the ſpace between *o* and P, in like manner as between C and F.

Then will the ſeveral parts of the profile be compleated, and repreſented; namely, BA the inner, and G*a* the outſide, ſlopes of the rampart, whoſe walk is BC; FE the inſide, and FG the crown of the parapet; CD the ſlope, and DE the top of the footbank; *a*H the berm or foreland; HI the ſcarp, KL the counterſcarp, and IK the bottom, of the ditch; LM the cover'd way; *o*N the ſlope, and NO the top, of the footbank; OP the inſide of the parapet, and PQ the ſlope of the glacis.

The paliſades *k* are put on the top NO of the footbank.

153. In ramparts coated with earth, it is uſual to ſet a row of paliſades in the front of the rampart, as at *h*, about 5 or 6 feet below the crown of the parapet. Theſe are not planted upright, but nearly horizontal, the point dripping a little below the level; and this work, which is called *fraiſing* or *ſtaccage*, is done to prevent ſurprizes by ſcaling, and alſo to hinder deſertions.

154.

154. In moſt ramparts coated with earth, whether of the town or outworks, it is uſual to plant on the berm, either a row of upright paliſades, as at f, or a quick-ſet hedge of thorn, which ſhould be kept conſtantly cut, to make it grow thick: Either of theſe methods ſerve to cover the troops in going their rounds. Sometimes both paliſades and hedge are uſed, the hedge ſtanding foremoſt.

The ſaliant angles of all earth works ſhould be rounded off; otherwiſe the weather would ſoon deſtroy the angular edges, and make them look worſe than the other parts.

155. *When the coating of the work is intire maſonry.* Fig. 23.

Having determined all the parts thro' the rampart to the line Gg, as at art. 152; in Gg take GI = 3 or 4 feet, for the upright face of the parapet; on I, with the radius of one foot, deſcribe a ſemicircle repreſenting the *cordon*, which is a large ſemicircular moulding that ranges along the whole front; take $g r$ equal to 18 feet, and draw $r c s t$ parallel to the ground line, and this repreſents the bottom of the foſs: Take $r c$ and its parallel Ia, each equal to 5 feet; draw the ſcarp Ic, and draw $a b$ parallel to Gg, which continue to about 6 feet below $r c$, and this line repreſents the back of the wall; thro' b draw a line $b d m n$ parallel to the ground line, and this repreſents the bottom line of the foundations, which is uſually about 6 feet below the bottoms of the foſſes, tho' in ſome caſes it muſt be more; and let the foundation line $b d$ project about 2 feet before the ſcarp line Ic: Draw a line about 3 feet behind the front line of the parapet GI, parallel to it, and the front wall of the parapet will be thereby repreſented; to which muſt be annexed, at G, a little projection, of about 6 inches in ſally and height, to expreſs the coving ſtone, and the outlines of the profile of the rampart will be compleated.

156. From the directions already given, it will be eaſy to conceive how to regulate the profiles of outworks, whether they are to be fronted with turf or maſonry; and according to art. 155, were the other profiles of the maſonry annexed in the figures 24 and 25; that of 24 being a tenail before the curtin, whereof no more than the parapet riſes above the ground level; and conſequently the walls to ſupport this work need not be ſo thick as thoſe are which ſuſtain the lateral thruſt of higher banks; and for the ſame reaſon, the counterſcarp walls are of a leſs ſtrength. In the ravelin, fig. 25, the front is half maſonry, or the walling is carried up to the ground level, and the front of the rampart and parapet is ſuppoſed to be coated with earth; but the walling in this caſe ſhould project about 2 or 3 feet before the foot of the rampart, in order to preſerve a proper berm.

157. The walks of all ramparts, and alſo the cover'd way, ſhould ſlope backwards, in order to carry off the rain; this ſloping may be about half an inch, or an inch in a foot.

158. The ſcarping uſually given to earth facings, is about 8 inches on 12, or the baſe of the ſlope is $\frac{2}{3}$ of the height; and the ſcarping generally allowed to fronts of maſonry is about $\frac{1}{5}$ or $\frac{1}{6}$ of its height; and with regard to the thickneſs of the walls, Mr. Vauban uſually allowed about 5 feet at top, and gradually thickned towards the bottom by their

ſcarping of 1 foot in 5 of height; and this profile he has experimented in the works of 150 towns, wherein he has directed the building of more than 4000000 of cubic yards of walling: But in order to add a greater ſtrength to his walls, he puts, at the diſtance of 18 feet on the inſide, buttreſſes built of rough ſtone, whoſe length was about the thickneſs of the wall at bottom, and their breadth, on a mean, about half the length; and theſe buttreſſes being carried up as high as the cordon, greatly contributed to take off the thruſt of the bank againſt the wall.

159. At the flanked angles of baſtions, and other works, the parapet ſhould riſe about a foot or two higher for about 12 or 14 yards on either ſide the angle, than along the reſt of the faces; and the ſame ſhould be obſerved for about 4 or 5 yards on each ſide of the more expoſed ſaliant angles of the cover'd way: For by theſe means, the troops ranged along thoſe faces will be ſomewhat better defended from the ricochet, or bounding ſhot.

160. *Of Irregular fortification.*

When a town or other place is to be fortified, it generally happens that the polygon which beſt circumſcribes its plan will be very irregular, and conſequently the fortifying of that polygon will not fall under the rules already given for regular fortification: It is therefore proper to point out to a learner how he may proceed on ſuch occaſions.

161. Let the plan of the place be circumſcribed, if poſſible, by a polygon, whoſe angles are all ſaliant, none leſs than 60 degrees, nor greater than 100; and neither of the ſides leſs than 200 yards, nor greater than 350: This polygon, which is to be the interior one, ſhould have its ſides not leſs diſtant from the houſes than 50 yards; and the fortification is to be made from the interior ſide.

Thro' every angle of the polygon draw a line biſecting it; and on theſe lines, continued without the polygon, lay from the angular points, the capitals (in the table, art. 86) of thoſe polygons, whoſe angles are neareſt to the angles in the given irregular polygon: Alſo on each ſide of the capital, from the ſaid angles, lay on the ſides of the polygon the demi-gorges correſponding to the capitals uſed.

Then the lines of defence being drawn, and the correſponding faces laid thereon, the *maſter line* of the fortification to the given irregular polygon may be readily compleated (as in art. 91); to which the rampart, foſs, and proper outworks may be annexed, as before ſhewn.

162. In the circumſcribing of the given place with a polygon proper to it, ſhould it ſo happen that the ſides, when drawn at the diſtance of 50 yards from the houſes, make a polygon very different from that above directed; then ſhould the poſitions and lengths of all thoſe lines, or of ſome of them, be changed, and tried various ways, when the ſituation will admit of thoſe various trials, until one is fitted to the place that will come near the foreſaid limits; notwithſtanding the ſides ſhould, in ſome places, run many more yards from the houſes than 50, and a ſpace of ground greater than the firſt propoſed ſpot ſhould be included within the polygon: For although by theſe means the fortification will be more extended, and thereby incur a greater expence both in building and defending; yet as it will, by its nearer approach to regularity, be ſtronger

in itſelf, and thereby more effectually anſwer the end of fortifying, the latter conſiderations may on ſome accounts be preferred to the former.

163. It ſhould be obſerved, that regularity is not ſtrictly confined to ſuch polygons only as can be circumſcribed by a circle, or nearly ſo; for a polygon inſcribed in an oval kind of figure will have a great regularity, and may be made pretty nearly equally ſtrong, by putting the ſtronger kind of outworks at the narrow ends: For as theſe ends, on account of their ſmall breadth, in proportion to the longer ſides, cannot flank the approaches of an enemy ſo well as the longer ſides, and the enemy thereby not neceſſitated to extend his works; conſequently the ſmaller ends may be more advantageouſly attacked, and therefore ſhould have their outworks of the ſtronger ſort.

164. If the ſituation is ſuch, that one or more of the ſides of the circumſcribing polygon cannot by any eaſy means be made leſs than 400 yards or more; then ſhould ſuch ſides be divided into parts of ſome number of yards, between 200 and 350, as many as its length will admit of, which may then be conſidered as compoſed of ſo many polygonal ſides: At every diviſion, make ſuch a baſtion as the limits will admit, taking care that the faces of each are commanded by the adjacent flanks of the next baſtions.

165. When any of the angles become too acute to make in that place a whole baſtion, the angle may be diminiſhed only on one ſide, making there a half baſtion, and let the other ſide be either left as one line, or make in it two or three ſmall flanks, in the nature of a redan (71); obſerving that the whole front is commanded by the flank of the next baſtion: Or ſhould the angle be too ſmall even for a half baſtion, then both ſides may be fortified in the manner of redans, and commanded from the flanks of the next baſtions: But in the caſe of theſe acute angles, the angular point ſhould be made very ſolid, and the ſides about ſuch angle ſhorter than the others.

166. Should the polygon have one or more entring angles which cannot be avoided; when that angle is near 90 degrees, and the adjacent ſides do not each exceed 250 yards; thoſe ſides, with the aſſiſtance of the flanks of the next baſtions, will very well defend one another, and alſo the entring angle: But ſhould the angle exceed 120 degrees, then put againſt that angle a work like a baſtion, if it can be; or if there is not room for the projection of the flanked angle, make but one face, obſerving that it be raked from one of the adjacent flanks.

167. Where a town has been fortified in the ancient manner, and has already a good rampart and foſs, ſuch a town may be put into a good ſtate of defence againſt the modern methods of attack, by adding outworks ſo diſpoſed as to cover the town wall, be mutually defended by one another, and commanded from the ramparts of the town; ſuch a place, with the outworks judiciouſly diſpoſed, may hold out as many days as a place formed on a regular plan; which has been evinced from the good defence made by ſeveral towns fortified in this manner.

168. There are a multitude of other things that might be ſaid on the buſineſs of irregular fortification, which, on account of the deſigned brevity of this tract, muſt be omitted: But after all, the beſt notions are acquired in theſe matters from ſtudying the plans of the fortified towns in ſeveral parts of the world. Collections of theſe plans may be met with at moſt print ſhops.

PART II.

Of Marine Fortifications.

SECTION I.

Of the kinds and properties of Harbours.

169. A Harbour or Port is a hollow cavity in the land, into which the ſea runs with a depth of water ſufficient to float ſhips or other veſſels capable of performing voyages on the ocean, and where ſuch veſſels may lie ſecured from the tempeſts of the ſea.

As harbours may be of very different forms, ſo there may be a multitude of ways propoſed for their defence: But herein the buſineſs will be confined to a few of the more common ſituations.

Harbours in general may be diſtinguiſhed into two kinds, namely, artificial and natural.

170. *Artificial harbours* are ſuch inlets of the coaſt, as are rendered ſafe for ſhipping to ride there, by building about its entrance certain works called Moles or Piers, which defend the ſhips within from the ſurges of the ſea without: And when the *moles* or *piers* can be brought ſo cloſe, as to be ſhut up by *ſluices* or *gates*, the harbour is then called a Bason: But the inner part of a harbour, where the ſhips ride in ſtill water, is uſually called the *baſon.*

All artificial ports of theſe kinds, are eaſily fortified by building on the moles or piers either batteries, redouts or forts, which command the entrance into the harbour: And as theſe works are uſually done at the time when the moles are made, there need no more be ſaid of them in this work.

171. *Natural harbours* are thoſe where the natural diſpoſition of the land forming them, is ſuch as contributes to the ſafety of the ſhipping therein, by ſheltering the veſſels from the fury of the ſea; and this happens in various manners, ſuch as a ſhoal lying off the harbour's entrance, which breaks the waves, and thereby keeps the water ſtill within; or by the points of land forming the harbour, ſtretching themſelves ſo far into the ſea, and coming ſo near to one another, that the ſurges are broke at their entrance; or by a narrow inlet that runs into the land for a conſiderable way, and where the ſhores near the entrance receiving the ſhock of the waves, renders the upper parts ſmooth enough to anchor in, of which kind are navigable rivers; or by a large deep bay, wherein iſlands, or other obſtructions, contribute to render a part ſecure for the riding of ſhips at anchor, &c. &c.

172. The properties of a good harbour, are, a ſufficient depth of water for large ſhips to enter at any time, whether the tide be in or out; good offing, and an eaſy acceſs out of all danger from the winds; free entrance, without rock or ſand bank; the entrance not too wide to be eaſily barred and defended upon occaſion; not ſubject to overflow, and where ſhips may lie cloſe to the keys; where the veſſels are ſheltered from all winds by the high mountains ſurrounding the harbour, and from whence there is an extended view of the ſea; laſtly, that the ſhipping therein be out of all danger, either from being ſet on fire, bombarded, or cannonaded from ſea by the ſhips of an enemy.

173. There are many places in which ſhips anchor, that lie open to the ſea, and are only ſafe to ride in when the weather is calm, or when particular winds blow; ſuch anchoring places are called *roads*.

SECTION II.

Of the fortifying of Roads and Harbours.

174. FIRST SORT. *When a town lies open to the ſea upon a curved or ſtrait bold ſhore, and has before it a ſufficient depth of water and good anchorage:* As ſuch places can afford ſhelter for ſhipping, only at certain times of the year, when they are generally ſure to have calm weather, or gentle gales, in which veſſels may ſafely ride at anchor, they cannot ſo well be ſecured from the attacks of an enemy, as in places more incloſed: However, the ſhipping lying there during the ſeaſon of trade, may be well defended by forts built near the water's edge on each ſide of the anchoring place; ſuch forts being ſo contrived as to have two or three batteries one higher than the other, and theſe furniſh'd with many cannon, carrying ſhot from 24 to 48 pounds, will awe the ſhips of an enemy in general from undertaking any thing againſt the veſſels that are riding in that road.

175. But in order to defend the town itſelf, there ſhould be a rampart or wall, well flanked, built along the ſhore, beſide the fortifications on the land ſide. The works along the ſhore ſhould be carried ſo near to the water's edge, that were any troops to land under the cannon of a fleet, they might not find any ground to intrench themſelves on.

176. Forts built on a bold ſhore, to which ſhips of war can come within muſket ſhot, are in general liable to be eaſily taken, unleſs ſome precautions are uſed: For as the batteries on ſhore are ſeldom raiſed much above the water's level, in order to be more certain of their mark; the troops poſted at the guns are liable to be commanded by the marines quartered in the round tops, and other elevated parts of the ſhips: However, this may be prevented, either by driving ſeveral rows of piles (which are long pieces of timber, or the bodies of trees, pointed, and ſhod with iron at one end when neceſſary) in the water before the fort, whereby the ſhipping cannot approach it; or by fixing along the battery a kind of *ſhed* made with planks of muſket proof, and covered with raw hides or earth, that they cannot be ſet on fire by combuſtibles thrown from the ſhips: Theſe ſheds are not only convenient to preſerve the troops poſted at the guns from muſket ſhot, during the time of an attack, but they would alſo preſerve the cannon and carriages from the weather at all times; for the expence of a few rough planks, uſed now and then to repair ſuch ſheds, added to the firſt coſt, might perhaps, in a length of time, be found of leſs expence than the gun carriages they would preſerve; and ſhould it turn out otherwiſe, the framing and planks might be prepared in time of peace, and ſet up only when there are apprehenſions of an attack; but it ſhould be obſerved to fix them ſo, as to be the leaſt expoſed to the cannon from the ſhips. In ſuch ſheds, as they would be open behind, the ſmoak would be ſoon diſſipated, and might be ſooner thrown

off by making holes in the ſhed over every gun; which holes may be covered by a ſhort plank raiſed before them.

177. SECOND SORT. *When a harbour, being a bay, has a ſhoal or ſmall iſland lying before its entrance:* Such a place is fortified by building a ſtrong fort on the iſland, in a place where it can command the entrance on both ſides, when the ſize of the iſland is not too large for this purpoſe: But when the mouth of the harbour, and the extent of the iſland, is too large for one fort on the iſland to guard the entrance, then two or more forts ſhould be raiſed thereon, in the moſt commodious places that can command the avenues to the bay.

178. Beſide the forts raiſed on ſuch an iſland or ſhoal before a harbour's entrance, there ſhould be others raiſed on the moſt convenient points of land forming the mouth of the bay; whereby the defence of the paſſage is made more ſecure, ſhould the ſhips of an enemy by any accident paſs the advanced defences.

179. When forts are thus built, it is not enough to contrive them in ſuch a manner that their batteries may annoy the ſhipping which attempt to paſs without leave; but they ſhould be alſo carefully fortified, to reſiſt attempts from an enemy aſhore; for ſhould this be neglected, a body of marines, or ſeamen, landing on the iſland or place where the battery or fort is, would fruſtrate the intention of ſuch fortifications or defences; of which there are many inſtances to be met with in hiſtory.

180. As there may be ſeveral ſpots about the points judged proper to erect the defences on, that will command in the manner as above, it is of conſiderable importance to know which will have moſt advantages, and feweſt diſadvantages; for both circumſtances are to be brought into the account, and that only choſen which has the moſt favourable balance. Thus, the ſoil ſhould be the firmeſt, and moſt capable to bear the cannon and building to be erected—Of a height ſufficient to be out of the reach of tides and floods, and not much higher than is barely neceſſary to avoid thoſe inconveniences; for the cannon commands beſt when near the water's level—A place difficult for an enemy to land in its neighbourhood; and if landed, where they may be incommoded in their march to the fort—A place where ſuccours may eaſily approach—Where the troops on duty may without much trouble obtain the conveniences of life—And where there are the feweſt noxious exhalations.

When the moſt convenient place for a fort or battery is choſen, the next thing to conſider, is whether the work is to be temporary or perpetual; that is, whether the work is only to ſerve for a preſent emergency, or to be kept in repair under a probability of its being frequently attacked; and whether the work be temporary or perpetual, it is neceſſary that it be fitted to the materials at hand, or that can be procured with the leaſt trouble and expence.

181. As it may frequently happen, that in ſuch ſituations here referred to, the paſſage between the iſland and main is rather too wide for cannon to command acroſs; therefore, if the place is of ſufficient importance, there may be many ways contrived to remedy this defect, when it is poſſible to be avoided. The beſt are thoſe which oblige ſhipping to keep in one track or channel; and when this can be accompliſhed, either by ſinking of old ſhipping, running out of moles, or contriving to

form ſand banks or ſhoals, or by any other means that the ſituation of the place can furniſh; then may forts or batteries be advanced ſo far into the water, as to command that channel: Or if the paſſage cannot be reduced to leſs than two channels, then a fort ſhould be erected, if poſſible, between them.

182. In the building of theſe works, great care ſhould be taken that the foundations are laid ſufficiently firm to ſupport the ſuperſtructure; and as theſe places are generally low, either in marſhy or ſandy ſituations, a great number of piles ſhould be drove into the ſoil, to the depth of 10, 20, 30, or more feet, according as they drive with more or leſs difficulty: If a quantity of ſuch piles be driven, at the diſtance of 12 or 18 inches from one another, over the place intended for the foundation, and the tops of them be cut level ſome feet below the ſurface, then may a floor of timber be laid over the tops of the piles, and the building raiſed thereon.

183. THIRD SORT. *When the harbour is in a bay, whoſe points forming the entrance ſtretch into the ſea, and approach one another within cannon ſhot:* Such a harbour is fortified by building on both ſides its entrance one or more forts; and if it is poſſible, let a fort be alſo built within the harbour's mouth, in ſuch a manner, that its cannon can rake the ſhipping fore and aft as they come in; for this would be a good reſerve, ſhould an enemy's fleet force their way between the forts which command the entrance: But ſhould there be no proper ſpot for ſuch a fort, then let others be erected on the moſt convenient points that can command the turning to the right and left within the mouth of the bay; for by theſe means an enemy will be obliged to endure a kind of running fire, which, if the forts be well conſtructed, he will ſcarcely be able to ſuſtain.

184. FOURTH SORT. *When a harbour is formed by a cluſter of iſlands:* Such a harbour is not difficult to fortify, when the channel between the iſlands is not too wide for the command of cannon from one or both ſhores; the directions how to place the forts in the foregoing caſes being equally applicable to this. And in places where the channel is more than cannon ſhot from either ſhore, the ſhipping that can ride there, muſt depend upon being defended from the batteries aſhore, as in the firſt caſe, when the ſhore is bold enough for the ſhips to run under the cannon.

185. FIFTH SORT. *When the harbour lies in an inlet or river ſome miles above its mouth.* If the paſſage to the port lies ſtraight, and can be commanded from ſide to ſide, then a fort built at each point of the entrance, and two others between them and the harbour, but not oppoſite to one another, unleſs the width of the channel requires it, will in moſt caſes be a proper ſecurity for the ſhipping in ſuch a harbour: And when the channel or river is winding, the forts ſhould be built where they can command a *reach* at leaſt; or be ſo placed at the bends, as to command two adjacent reaches; for as veſſels muſt tack near the forts ſo placed, they will at thoſe times be more under the command of the batteries, than they would be when ſailing by them on a direct courſe.

In the directions for the placing of forts in this, and the other caſes, there has been no mention of the figure which it would be moſt proper to conſtruct them of; for the engineer, who has the charge of ſuch works, generally does, or ſhould take care, to fit the ſpot with a figure properly adapted to it: But for the ſake of the mariner, it was judged proper to point out the methods uſually taken on ſuch occaſions.

186. *Of the figure and ſize of Forts.*

Beſide the forts deſcribed as redouts (art. 68, 70), there are many others, ſuch as ſquares, pentagons, hexagons, or the halves of theſe figures, which are fortified with intire baſtions, by much the ſame kinds of conſtructions, as are the polygons in the table art. 86; only the meaſures of the *exterior ſide*, *normal* and *face*, are much leſs than thoſe for a town; and are uſually about the following numbers.

Make the ſide or front about 180 yards; the normal one ſeventh, or one ſixth of the ſide; and the face about twice the normal, or a little leſs; with a ditch, if neceſſary, of about 20 yards broad; a rampart broad enough for a platform, and a parapet of about 12 feet thick.

The exterior ſides of forts may be conſiderably leſs or greater than 180 yards, even between the limits of 60 yards to 200; according to the ſize of the ſpot on which it is to be built, joined to the importance of the place it is to defend: For it would be a great abſurdity, either to build a large expenſive fort to ſecure a harbour or port of little more conſequence than to give ſhelter to a few fiſhing boats; or, on the contrary, to build a ſmall trifling work to guard a haven where many ſhips of the utmoſt importance are laid up, or riding at anchor.

It is not always neceſſary, or even convenient, to make theſe forts on figures perfectly regular; for the ſituation may require ſome of its ſides to be ſhorter than others: Neither is it neceſſary that the figures ſhould be fortified with baſtions, or half baſtions, at the angles; for there are many caſes where it will anſwer the purpoſe equally well, or even better, to make a baſtion on the ſide of a figure towards the middle; but then the faces of the baſtion ſhould be ſo drawn, that they may be raked from the extremities of that ſide, by a defence of at leaſt 10 or 12 yards.

187. *Of proper Forts, and their diſpoſition.*

If the place on which the fort is to be built is a ſpot ſurrounded with water, forming a channel on both ſides; then the figure is to be diſpoſed, ſo as to have either one or two of its fronts turned towards each channel, whereby the batteries in the flanks will ſcour both up and down the ſtream, while thoſe in the faces and curtins command the paſſage directly before them. That part to ſeaward, may either have a front extended along it, or have one of the points of the figure directed that way, according as it may be judged moſt convenient; and if before theſe fronts there is any place at which an enemy can land, then one or more batteries ſhould be ſo formed, that their guns may be brought to bear on that landing place; and if this be not thought ſufficient, a ſmall outwork ſhould be built near that place, to make the landing more dangerous; and on account of the convenience of landing, the fort ſhould be furniſhed with a ditch, covered way, and glacis: The part next the harbour will be ſufficiently ſecured by a line thrown up properly flanked. Should the ſituation be on a rock, where there is no danger of an enemy's landing; then a good line, capable of covering the troops and cannon, will ſuffice. *If there is only a channel on one ſide fit for ſhipping to paſs through*; then that ſide ſhould be fortified as in the former caſe; and leaſt the enemy's boats ſhould get through on the other ſide, it ſhould be alſo put in a ſtate of defence: But here a ſlight redan, furniſhed with a few pieces of ſmall cannon, may be found a ſufficient defence againſt the boats.

188. When a fort is built on a point of the main, the ſame kind of diſpoſition uſed in the foregoing caſe, next to the channel, will alſo obtain in this; but it is neceſſary to take proper care of the land ſide, which in this caſe is more liable to be attacked than in the former. In the fortifying of the land ſide, the works ſhould be proportioned to the ſtrength of the enemy that may probably ever appear before it: For there are many places, where there is no likelihood of ever ſeeing an enemy ſtronger than the force which can be exerted by a fleet of three or four ſhips of war; and as theſe cannot be furniſhed ſufficiently for undertaking a regular land ſiege, therefore a well flanked line, with a ditch, if properly defended, will ſecure the place againſt the attacks of ſailors or marines unprovided with artillery: Or ſhould a few pieces be brought againſt the place, their paſſage to it will be very dangerous, unleſs they can be brought near enough to act under cover; and to leave ſuch a cover would be an unpardonable overſight in thoſe who had the care of conſtructing that fort. But when the importance of a place may bring before it a large fleet, and a land army properly appointed, then ſhould the fortifications on the land ſide be put in a ſtate capable of ſuſtaining a vigorous ſiege.

There are many low points on which batteries may be raiſed for the defence of a channel, over which a lofty ſhip may have a conſiderable command: In ſuch forts proper traverſes ſhould be placed, that the line of the battery be not raked by the ſhips guns.

189. In the conſtructions of all forts, it ſhould be remembered, that the figure of feweſt ſides and baſtions, that can probably anſwer the expected defence, is ever to be preferred; as the works on ſuch plans are ſooner executed, and with leſs expence; beſides, fewer troops will ſerve, and they are more readily brought together in caſes of neceſſity: And with regard to the executive part of ſuch works, enough has been already ſaid, obſerving that where ſtone and brick are ſcarce, and there is plenty of wood, then timber works are to be moſt uſed; and, on the contrary, ſtone or brick earth being plenty, and wood ſcarce, maſonry is to be preferred; taking care never to uſe ſea water in the lime, nor to make the parapet intirely of ſtone; for the ſplinters drove about by an enemy's cannon, will make it dangerous for the defendants to continue their poſts.

SECTION III.

190. *Of the fortifying harbours by Booms.*

Notwithſtanding the forts built for the ſecurity of a harbour, or paſſage, there are many inſtances that may be produced to ſhew that they alone are not ſufficient. The great Sir Walter Rawleigh ſays, " In " this age, a valiant and judicious *man of war* will not fear to paſs by " the beſt appointed fort of Europe with the help of a good tide, and a " leading gale of wind; no, tho' 40 pieces of great artillery open their " mouths againſt him, and threaten to tear him in pieces.

" In the beginning of Queen Elizabeth's reign, when Denmark and " Sweden were at war, our Eaſtland fleet, bound for Liefland, was forbidden by the King of Denmark to trade with the ſubjects of his " enemies, and he threatned to ſink their ſhips if they came thro' the " ſtreights of Elſeneur. Notwithſtanding this, our merchants, having " a ſhip of her majeſty's, called the Minion, to defend them, made the " adventure; and ſuſtaining ſome vollies of ſhot, kept on their courſe. " The king made all the proviſion he could to ſtop them on their return: But the Minion, commanded (as I take it) by William Burrough, leading the way, did not only paſs with little loſs, but did beat " down with artillery a great part of the fort of Elſeneur, which at that " time was not ſo well rampar'd, as now perhaps it is; and the fleet of " merchants that followed him went thro' without any wound received. " Neither was it long ſince, that the Duke of *Parma* beſieging *Antwerp*, " and finding no poſſibility to maſter it otherwiſe than by famine, laid " his cannon on the bank of the river, ſo well to purpoſe, that he " thought it impoſſible for the leaſt boat to paſs by: Yet the Hollanders " and Zealanders, not blown up by any wind of glory, but coming to " find a good market for their butter and cheeſe, even the poor men " attending their profit, when all things were extream dear at Antwerp, " paſſed in boats of ten or twelve tun, by the mouth of the duke's cannon, in deſpight of them, when a ſtrong weſterly wind and tide of " flood favoured them; as alſo with a contrary wind, and ebbing tide, " they returned back again: So as he was forced in the end to build " his *ſtockado* overthwart the river, to his marvelous trouble and charge. " The fort of St. Philip terrified us not in the year 1596, when we entered the port at *Cadiz*; neither did the fort at *Puntal*, when we were " entered, beat us from our anchoring by it, tho' it played upon us with " four demi-cannon, within point blank, from ſix in the morning till " twelve at noon. The ſiege of *Oſtend*, and of many other places, may " be given for proof, how hard a matter it is to ſtop the paſſage of a good " ſhip, without another to encounter it. Yet it is true, that where a " fort is ſo ſet as that of *Angra* in *Tercera*, that there is no paſſing along " beſide it, or that ſhips are driven to turn upon a bow-line towards it, " wanting all help of wind and tide; there, and in ſuch places, it is of " great uſe and fearful: Otherwiſe not."

But ſince Sir Walter's time, the Sound has been better fortified, yet in 1700 Sir George Rook paſſed it, notwithſtanding the Daniſh fleet lay to impede his paſſage. The actions at Londonderry, Vigo, Porto-bello, Carthagena, and at many other places, are all ſufficient proofs, that neither forts nor caſtles can ſtop the enterprizes of the brave; and therefore it has been judged proper on many occaſions, beſides forts and batteries, to lay booms and other obſtructions in a ſtream, to ſecure the ſhipping there from the attacks of a powerful enemy.

191. *To lay a Boom.*

Provide a great number of wooden battlings or ſpars of about 20, 30, or 40 feet long, more or leſs, and between 5 and 10 inches diameter: Then moor two boats, having a ſheet anchor in each, in the place near one ſide of the river where it is intended the boom ſhall begin; bend two cables to theſe anchors, and round them place the ſpars or poles, frapping on each with ratling ſtuff, or better with four inch rope, until the boom is 7, 8, 9, 10, or more feet diameter (according to the hands employed), the cables being in the middle; next, with iron hoops rivetted together, worm the boom, and drive thro' the hoop a nail into almoſt ever ſpar: After having wrought a good birth from the anchors, drop them, and continue the work till it is brought near the other edge of the river, and there drop two anchors more with the cables bent to them: Then over all laſh the ſpare yards and top-maſts with the top chains, ſo far as the channel goes.

To that part of the cable in the channel that makes the boom, let other cables be faſtened, and theſe bent to anchors laid down the ſtream; over the clinch of theſe cables let battlings or ſpars be wrought for near ten fathoms down the ſtream, that the enemy may not cut theſe cables: Theſe will be ſerviceable when the enemy's ſhips come *ſtemlings* againſt it; for if he force it in one place, the whole will not be opened by that fracture.

In places where wood is ſcarce, and proper ſpars are not to be readily had; or in caſes where there is not time ſufficient to prepare them; it may be found ſufficient to woold two cables together with old ropes, laſhing to them the oars, top-maſts, and yards, and worming the whole about with iron hoops; and let every part be well *payed* with pitch, and ſmall gravel ſtrewed on it while the pitch is warm. A boom ſo prepared cannot be eaſily cut.

If on any particular occaſion it ſhould be found convenient and ſafe to open the paſſage, it may be done by tripping the anchors that are on one ſhore and thoſe down the ſtream, whereby the boats may ſwing down the ſtream upon the ebb, and upon the flood the boom may be relaid, if the enemy appear in ſight, which he muſt do the firſt of the tide, for upon the ebb there is no danger of his coming; becauſe, if the wind be right in, a prudent enemy will not adventure againſt the tide, a ſhip then making ſuch wild ſteerage; and ſhould ſhe ground, ſhe muſt lie there till flood, which may prove fatal to her from the batteries aſhore; and againſt both wind and tide the enemy cannot come in. On the contrary, ſhould the boom be carried up the flood, and the enemy appear at the beginning of the next flood, the boom cannot be relaid till the ebb, and before that time the enemy may have accompliſhed his deſign.

192. If there be good ſtore of timber at hand, then a *ſtockado* may be made by driving ſeveral rows of piles in the channel before the boom; or ſhould the depth of water be too great for this work, the trees may be uſefully applied, by making a raft to ride before the boom by good anchors, obſerving that the cables are ſo made faſt, that the enemy can't come to cut them: Theſe rafts will be of ſingular uſe in putting the enemy into diſorder, by laying rubbiſh upon them to make fires of when the enemy appears, which will put him into ſome conſternation, and perhaps may cauſe him to chop to anchor, and loſe time or his tide; and this may be done each flood, obſerving not to have the ſmoke drive into the works, which might give the enemy too great an advantage.

193. *To lay a boom in a ſtreight channel.*

Suppoſe the wind for the moſt part to blow obliquely acroſs the river or channel on the ſtarboard quarter going up the river: Now if the boom be laid directly thwart the channel, the ſhips coming with the tide of flood and a leading gale will run ſtemlings againſt it, and ſo hazard its breaking, by ſtriking with a force that comes direct; whereas, could the boom be laid obliquely thwart the river, nearly in a line with the wind, ſo as the ſhip muſt take it with her bow, the blow would be diverted by the ſhip's caſting; becauſe in this poſition the enemy cannot run ſtemlings againſt it; for in ſailing up the river, the ſhip muſt be near before the helm; and to bring her head to the boom, the helm muſt be put down, and then it is ten to one whether ſhe come too ſo nicely as to take the boom: Not to mention the miſtakes, in a confuſion, committed by the man at the *helm*, and he upon the *cond*, nor the ſmoak; for excluſive of all theſe, it may be taken for granted the ſhip would caſt along ſide the boom: Then the batteries at the end of the boom on the larboard ſide would rake him fore and aft, while the oppoſite batteries on the ſtarboard ſide playing on his broadſide with *double-round* and *partridge*, muſt make a great ſlaughter among his men cutting at the *boom*. And ſhould he not ſwing along ſide the boom, but lie ſtemling againſt it, then will the batteries on the ſtarboard ſide the river, which are to be made above the weather end of the boom, rake him fore and aft, while thoſe on the larboard ſide, againſt the leeward end, play on his broadſide.

194. The ſhips within the boom, which it is to protect, ſhould be moor'd in a kind of half-moon, with their broadſides flanking the boom. And ſeveral old ſhips, or thoſe the leaſt uſeful, may be ſunk as ſoon as a ſignal, ſignifying that the boom will be cut, is made at one of the forts which defend it; for this purpoſe, thoſe ſhips ſhould have large ſcuttles ready cut: And for a farther ſecurity, it would be very proper to have a ſmall boom to divert the enemy, that the ſhips may be ſunk in the channel before he boards them.

As to the reſt of the ſhips, they are left to their commanders judgment; and if there is no other remedy, the people may get aſhore to windward if they can, and there make the beſt defence in their power againſt the enemy's boats and fireſhips. From duly weighing the whole of theſe circumſtances, it will be found that the chief ſtrength is in the boom; therefore if a double, triple, or fourfold boom was laid, if the materials could be procured, and the value of the ſhipping and cargoes were of ſufficient importance, it would make the place ſo much the ſtronger, and the enterprize of the enemy more hazardous. In ſtretching theſe booms, the trouble of many anchors may be ſpared, by making all the cables faſt to the firſt, and ſo let them float in a bight, and by a ſmall anchor ride upon the ebb, to keep clear of one another.

195. *To ſet up a boom in the bend of a river.*

From the point formed by a bend, ſtretch two bombs acroſs the channel, one towards the middle of the oppoſite bight, and the other ſo much higher, as to lie directly thwart the channel, leaving a kind of angular ſpace between them.

Next the point from whence the two booms ſtretch, erect a proper fort or battery to command the channel both below and above the bend.

On the other ſide the river, erect another fort or battery againſt the bight a little above the end of the lower boom, and ſo diſpoſed, that its cannon may rake the channel coming up to the boom, as well as command both the booms.

A boom being thus diſpoſed, it is a great chance if a ſhip anſwer her helm ſo timely in *bearing* or *loofing* about the point as to take it ſtemlings, and if ſhe ſmite it with her bow, ſhe caſts; and in either caſe ſhe will be raked fore and aft by one fort, and have her broadſide battered by the other.

Let ſome old veſſels be fitted up for fireſhips, and placed between the two booms; from each ſhip let two hawſers be carried aſhore, one on each ſide, and fixed to cramps ſet up; ſo that as ſoon as the enemy has paſſed the firſt boom, theſe ſhips being ſet on fire, and heaved in their way, nothing can hinder the enemy's deſtruction: As ſoon as fire is ſet to the train, the boat may pull aſhore, under covert of the ſhip, without any apparent danger; for ſuch will be the enemy's conſternation, that they'll ſoon leave firing. The hawſers may be faſtened to clamps below the water-line, that they be not burnt, nor in ſight of the enemy to cut them. If the fireſhip is clapt aboard the weathermoſt ſhip, they may be both heaved together aboard another to leeward.

The ſhips to be defended, may be moored in a half moon, with their broadſides ſo laid, as to batter the enemy when he attempts the boom: And if other works than what are here directed be judged neceſſary, they muſt be adapted to the ſituation of the place.

196. When no ſtrong attacks by land are to be fear'd, the mooring of ſhips behind a point is beſt, on account of laying the boom: Now ſhould the boom be forced, which muſt be upon the flood, a fireſhip, inſtead of falling on board a ſhip thus moored, will by the tide be hurried beyond her; and if the place is any ways favourable to the ſhips moored there, it will be found impracticable to board a ſhip thus moor'd, with ſuch a wind and tide as the enemy muſt have to break the boom, unleſs he expoſe his boats in carrying out an anchor to *warp* over, which will be a very dangerous attempt; or ſome unaccountable accident intervene.

197.

197. It may be objected, that ſhips thus moor'd cannot bring their broadſides to bear upon the enemy when coming to force the boom; and that they may be battered by the enemy over the point. To this it may be anſwered, firſt: It is no matter whether the broadſides do or not, for perhaps it might be the beſt way to get the guns aſhore, if there is time, to be there uſed; and to put the ſmaller ſort only on the lower deck, and turned to flank the boom. Secondly, The enemy will have but an uncomfortable *birth* in lying to batter the ſhips over the point, as they will have to deal with the fire from the fortifications aſhore. What is here ſaid, is only to be underſtood when five or ſix ſhips are to be defended; for the wake of a point would not hold any conſiderable fleet.

198. *Maxims to be obſerved in fortifying a harbour and mooring the ſhipping therein.*

I. Let all the land marks be removed that may direct the enemy's ſteerage into, or up the river or harbour, when there is a probability of an attack.

II. Chooſe ſuch a place if poſſible for erecting the works on, that cannot be laid under water, either by haſty rains, or by any art of the enemy.

III. Let the eminencies which command the works within cannon ſhot, be ſecured by erecting ſmall forts on them, furniſhed with ſmall cannon.

IV. All woods within cannon ſhot of the fortifications are to be cut down, and the timber employed about the works.

V. Secure a ſpring of freſh water by a fort and proper guard.

VI. Take all the buoys from the anchors that ride the booms, that the enemy may not trip them.

VII. Let the powder and other munitions be ſeparated and kept in different places, that if an accident happens, the whole may not be deſtroyed.

VIII. The ſhips ſhould not be poſted near any town or village, unleſs they are intended to cover that place, or the thing be unavoidable; leſt the ſhot and bombs which miſs the ſhips deſtroy the town.

IX. The ſhips ſhould never be moor'd before the fortifications.

X. Moor the ſhips ſo as to rake the enemy fore and aft when he batters the works.

XI. Let not the ſhips when moor'd touch one another, that the enemy may be obliged to burn each ſhip ſingly.

XII. Unrig the ſhips, and ſtrip the ſhrowds from the maſt-head, that the graplings of fireſhips may have no hold.

XIII. Let the ſails be carried aſhore for tents, and moſt of the gunner's ſtores; that if the worſt happen to the ſhips, there may be ſtore of ammunition for the forts.

XIV. Unleſs the cargo be aſhore, let not the cheſts nor cloths of any perſon, from the captain to the ſwabber, be carried out of the ſhip; whereby every man may have ſome inducement to exert himſelf in the defence.

XV. Let outguards and centinels be placed upon and near the banks of the river or harbour; and let ſome hands in nimble boats, armed, paſs down the ſtream each night to watch the motions of the enemy.

SECTION IV.

199. *Of the mooring of ſhips in fortified harbours.*

Before the boom is laid, it will be neceſſary to appoint the place where to moor the veſſels, that they may be beſt ſecured from the enemy's fireſhips, and yet annoy their men of war; and as this can be only done either in the ſtream or out of it, the advantages and diſadvantages reſulting in both caſes will be here conſidered.

200. *Conſiderations in mooring with regard to the ſtream.*

First. *The advantages an enemy has of a ſhip moor'd in the ſtream.*

1ſt. A ſhip moor'd in the ſtream will find ſome difficulty in bringing her broadſide to gaul an enemy in his approach, who always comes with the ſtream; and if the tide runs too ſwift for one to lie thwart, it certainly does ſo for the other; both having ground tackle equally good.

2d. In this ſituation there is no hindering a fireſhip, that has paſſed the boom, from being aboard you, as none but the chaſe guns can be brought to bear on him; and ſhould you heave thwart, he will be the ſurer of grapling you, unleſs by bringing your whole broadſide to bear, you ſink him; for ſhould the officer, thro' want of courage, forſake the fireſhip, yet the tide will bring him aboard: Moreover, in ſuch a poſition the enemy's ſhips of war may board you, and then your batteries aſhore are uſeleſs.

3d. In riding in the ſtream, the cables are expoſed to the enemy; which if hit by a chance ſhot, the ſhip will ſwing upon the tide, and ſo the enemy have the opportunity of raking you fore and aft; and if the enemy has any conduct, he may lay his anchors ſo as his cables ſhall be ſecured from your ſhot.

4th. Should you moor thwart the ſtream, the enemy may drop a ſmall anchor out aſtern, veer thwart your hawſe, and ſo conſtrain you to alter your poſition, or rake you fore and aft.

5th. In riding thwart the ſtream, the cables by bearing a more than ordinary ſtrain are apt to break, or ſtart an anchor; whereby the ſhip ſwinging on the tide, it is a great chance but the other anchor ſtarts, and ſhe ſwing to leeward. But theſe advantages are only on the enemy's ſide while the tide ſets in; for the defendants have them when the tide ſets out: Therefore, in ſuch places where the ſtream runs continually out, the beſt way is to moor in it, if the wind does not blow always in.

201. Secondly. *The advantages a ſhip moor'd in a ſtream has over an enemy.*

1ſt. A ſhip moor'd thwart the tide, lies convenient to rake an enemy fore and aft in his approach, and ſo may do him a conſiderable damage before he is thwart the ſtream to batter.

2d. In riding thus in the ſtream, according to the common ſituation of rivers, the enemy cannot batter you under covert.

202. Thirdly. *A ſhip moor'd out of the ſtream has theſe diſadvantages.*

1ſt. That ſhe cannot rake the enemy fore and aft ſo well as while lying in the ſtream; unleſs by ſome particular ſituation of the place.

2d. The

2d. The enemy's men are not much expoſed in mooring; for it is but dropping his anchor and he may veer along your ſide; or if you lie thwart the river, acroſs your hawſe: But this may be prevented by riding in the wake of a point; for, ſhould the enemy drop anchor before he be about the point, he cannot veer along ſide; and if he let go his anchor after he is about the point, he may be aſtern before he is brought up.

203. FOURTHLY. *A ſhip moor'd out of the ſtream has theſe advantages.*

1ſt. There is no danger of the fireſhips driving aboard her, unleſs directed by a ſtrong wind: And for the ſame reaſon, the enemy cannot be thwart your hawſe, unleſs he tows there with his boats, and then they and their crews are expoſed to your cannon.

2d. A ſhip thus moor'd is in no danger of driving ſhould her cables be ſhot, if it is calm, as it commonly happens in engagements.

Conſiderations in mooring with regard to the wind.

204. FIRST. *With regard to windward.*

Beſide the advantage of being free from the ſmoke, you may cauſe the enemy to drive to leeward, ſhould you hit his moorings; and if he trys to heave off by carrying an anchor to windward, his boats will be expoſed to your cannon; and if the boats *lay to paſs*, his ſhip while he heaves will be raked fore and aft, which muſt do great execution among his men while they ſtand thick at the capſtan: But it is highly probable, a ſhip ſo grounded could not be got off.

When to windward, the cables are cover'd from the enemy by the ſhip, and may be *ſeized* to *clamps* and *cleats* nailed to the ſide, and ſo the mooring ſecured from random ſhot: And this ought to be carefully done for preventing the only diſadvantage that attends ſhips moor'd to windward, which is, that if their cables are ſhot they drive out upon the enemy, or ſwing head at wind; if the former, they may be boarded by the enemy's fireſhips, or ſhips of war, and then your precautions are rendered fruitleſs; if the latter, they may be raked fore and aft by the enemy; and if neither of theſe happen, the ſhip may drive to leeward and be grounded.

205. SECONDLY. *With regard to leeward.*

A ſhip ſo moor'd cannot prevent the enemy's being ſent on board, unleſs a ſhoal or ſtockado lie between them.

In this poſition, ſhould you ſhoot the enemy's cables through his careleſsneſs in covering them with his hull; yet as he drives aſhore, or upon you, his boats are cover'd with his hull while they carry an anchor to windward to heave off.

Beſides your moorings lying to windward, are expoſed to the enemy; which ſhould they be cut, you will ſwing head at wind, and in that poſition be raked fore and aft; and if you attempt to carry out an anchor to heave your broadſide againſt the enemy, your boats will be too much under his command; indeed, inſtead of carrying out an anchor, it may be beſt to clap a ſpring upon the cable, but this will fail if the ſhip is too near the ſhore.

Upon the whole, it appears beſt to moor to the windward in the wake of a low point, when ſuch a ſituation can be obtained; but the circumſtances being ſo various, it muſt be left to the judgment of the commander, who, if he rightly conſiders what has been ſaid, will chuſe for the beſt.

SECTION

SECTION V.

206. *Of ſome remarkable actions concerning the attack of ſhips in fortified harbours.*

Having ſhewn the methods that have been directed by experienced men, to be uſed in the defence of harbours, we ſhall now think of cloſing this work with the accounts of ſome of the moſt remarkable actions recorded within the laſt 100 years, wherein the Engliſh have had any ſhare; and this was thought uſeful on two accounts: Firſt, as examples to the preceding precepts; and ſecondly, to point out to the young mariner the means by which many have acquired great reputation and honour.

207. *The battle of Santa Cruz in the year* 1657.

Santa Cruz is a town and bay on the weſt ſide of the iſland of Teneriff, one of the Canary iſlands: The bay, which lies rather open than incloſed, has deep water near in ſhore; but the beſt anchoring is about half a mile from ſhore, in 30, 40, or 50 fathoms water, black ſlimy ground: If there be many ſhips, they muſt ride cloſe one by another. The ſhore is generally high land, and in moſt places is ſteep to the water.

Admiral Blake lying with ſome ſhips near Cadiz, to watch for the return of the Spaniſh plate fleet, had intelligence they were in the bay of Santa Cruz, in the iſland of Teneriff; hereupon he broke ground the 13th of April, and on the 20th arrived at Santa Cruz, where he found the Spaniſh fleet, to the number of ſixteen, moor'd in the bay in a half moon: Near the mouth of the bay was a caſtle well furniſhed with heavy cannon; and beſides that, there were ſeven forts round about the bay, with 6, 4, or 3 great guns in each, all united by a line of communication from fort to fort, and well lined with muſketeers. *Don Diego Diagues*, the Spaniſh general of the fleet, upon ſight of the Engliſh fleet, cauſed the ten ſmaller ſhips to be moored cloſe to the ſhore, and ſet ſix great galleons, well mann'd, further out at anchor, with their broad ſides to ſea; in this poſture the Spaniſh admiral vainly thought himſelf ſo ſecure, that a Dutch merchant ſhip going out of the harbour, he ſent a meſſage by him to *Blake*, *that he might now come if he durſt.*

The Engliſh admiral having well viewed their poſture, ſaw it would be impoſſible to bring off the galleons; however, he reſolved to burn them, and to that end ſent in Captain *Stayner*, commander of the *Speaker frigate*, with a ſquadron to attack them: He ſoon forced his paſſage into the bay, whilſt other frigates entertained the *forts* and *lines* with continual broadſides: Theſe were preſently ſupported by *Blake* himſelf with the whole fleet, who placing ſome of his ſhips to batter the caſtles and other forts, he with *Stayner* continued to engage the galleons; over whom, in ſix hours, he gained (notwithſtanding they had reinforcements of men ſeveral times from the ſhore) a complete victory, ſet them on fire, and every one of them was burnt to the water's edge. They had no ſooner done this, than the wind luckily turn'd, and carried the fleet, without the loſs of one ſhip, out of the bay, and put them ſafe to ſea again.

208. *The action at Londonderry in the year* 1689.

Londonderry is a ſmall but pretty ſtrong town in the north of Ireland; it ſtands on the weſt ſide of the river *Loughfoyle*, about three miles from a lake of the ſame name; which is about ten miles broad and fifteen miles long, communicating with the ſea by a ſtreight of about a mile broad, ſo that the town ſtands about 18 miles from the ſea: The river next the town is about $\frac{1}{4}$ of a mile over, and keeps this breadth nearly, between the town and lake, where its mouth is defended by Culmore fort, which is a large ſquare with four baſtions.

This town was beſieged by the Iriſh and French in the year 1689, and the gariſon brought into great ſtraits for want of proviſions, the beſiegers having ſtrongly fortified the river. There was a boom framed of a chain and cables, covered with timbers, ſtretched acroſs the river about two miles below the town, from a point on the eaſt ſide: Each end of the boom was defended by a fort. Between the boom and Culmore fort were two others, one on each ſide the river, and another fort above the boom oppoſite the town. The ſides of that narrow river were intrenched and lined with muſketeers, and ſeveral boats were ſunk, and ſtockadoes drove, armed with large iron ſpikes.

Notwithſtanding all theſe preparations, the boom was forced, the town relieved, and the ſiege raiſed, by the aſſiſtance brought by three ſhips only, in the following manner: The *Montjoy of Derry*, commanded by Captain *Browning*, and the *Phœnix of Colrain*, by Captain *Douglas*, being both loaden with proviſion, were ſent towards the town, under the convoy of the *Dartmouth* frigate, commanded by Captain *John Leake*. They were forced to ſtand a furious fire of the enemy from Culmore fort, and from the other forts and intrenchments on both ſides of the river, which they received and returned with the greateſt bravery imaginable. The Montjoy made a little ſtop at the boom, occaſioned by her rebound, after ſtriking and breaking it, ſo that ſhe was run aground. Upon this the enemy gave a loud and joyful ſhout (tho' a dreadful one to the beſieged), fired all their guns upon her, and were preparing their boats to board her. The trouble and concern of the beſieged, to ſee their laſt hopes diſappointed, is not to be expreſſed; but by great providence, firing a broadſide, the ſhock looſened the ſhip ſo, that ſhe got clear and paſſed the boom. Captain *Douglas* was engaged all this while, and the *Dartmouth* gave the enemy very warm entertainment, till at length the three ſhips, having overcome the great difficulty of breaking and paſſing the boom, got up to the city, and brought unſpeakable joy and tranſport to a gariſon, which reckoned only upon two days life, having nothing left but nine lean horſes, and a pint of meal to each man. This brave and ſucceſsful undertaking ſo diſcouraged the enemy, that they raiſed the ſiege the next day, and retreated by night in the utmoſt confuſion, but made a moſt miſerable havock in the country, by robbing and burning all before them for ſeveral miles.

The boom appears to have been laid directly thwart the ſtream, and ſo was eaſier to force, than if had been laid obliquely acroſs.

209. *The action at Gibralter in the year* 1693.

The Engliſh fleet under the command of *Sir George Rook* and *Sir Thomas Hobſon* were convoying of a very large fleet of merchant ſhips towards the Mediterranean; but falling in with the French fleet under the command of Admiral *Tourville*, the Engliſh admiral gave the ſignal for the merchantmen to ſhift for themſelves; and among others, four heavy laden Turkymen; namely, the *Shandois*, the *Italian merchant*, the *Aſia*, and the *Loyalty*, ſtood away for the Spaniſh ports, and put into the bay of Gibralter; where the commanders of the Turky ſhips, being hindered from proſecuting their voyage by ſome diſſention on board, and the fear of the French fleet, thought proper to fortify themſelves.

For this purpoſe, the commanders poſted their four ſhips in a line within the new mole, which ſtretches to the NW., with their broadſides flanking towards the north, or entrance into the mole; the ſhips were unrigg'd, and conſequently having no ſails to manage, they turn'd all hands to the cannon, bringing as many as they conveniently could to bear on one ſide.

On the SE. end of the mole, or land ſide, was a caſtle, in which was mounted ten ſmall cannon, four pointing into the bay towards the weſt, three commanding the mole, and the other flanking the NE. ſhore: Oppoſite to the mole-head was a kind of redent, very advantageouſly built to flank the entrance into the mole; but neither on this, nor the mole-head, had the Spaniards any cannon. From the caſtle there ran northward a line of communication, or a ſtrong ſtone wall, to the ſouth end of the town, where was a battery of cannon, but too far from the mole to be of any ſervice in defending it.

The Engliſh ſtretch'd a cable from the mole-head to the redent, the ends being bent to two ſheet anchors, and to this cable they laſhed their *ſpare yards* and *top-maſts*. Upon the mole-head was planted ſix of the Shandois's guns to flank the boom, and this battery was committed to the care of ſome Engliſh ſeamen, who behaved themſelves very well. The commanders intended to plant ſome guns at the other end of the boom, upon the redent, but being obliged to go thro' the caſtle, the draw-bridge broke, and down went the firſt gun that came upon it, into a ditch near forty feet deep, with ſome of the Shandois's men; by this it may be judged in what condition the Spaniſh works and gariſon were.

This was the poſture things were in, when the French came into the bay with fourteen or ſixteen men of war and two bomb-ketches; and ſtanding within ſhot of the caſtle, the Spaniards ſhewed their dexterity in managing their ordnance, by firing about one ſhot in half an hour. The commanders perceiving their aukwardneſs, ſent a quartermaſter from on board the Shandois, and the gunner's mate of the Loyalty, to their aſſiſtance, and ſome dozens of cartouches; but thro' want of judgment in the Spaniards, they were both blown up. All this time not a ſhip could bring a gun to bear, and ſo without any damage the enemy paſſed by into the bay where they anchored.

In the afternoon they ſent down two *men of war* to view in what poſture the ſhips lay; as ſoon as they came within ſhot, the Engliſh fired briſkly at them, but before many broadſides were returned, they ſtood away to their ſquadron, and continued quiet that day: Next morning a ſhip of upwards of fifty guns came towards the boom, and it proving calm when ſhe came within ſhot, there was pretty briſk firing on both ſides, on which ſhe endeavoured to tow off, but her boats were ſunk from the battery on the mole-head, and had not boats come from the ſquadron to her aſſiſtance, ſhe had moſt certainly been ſunk, having above 100 cannon playing upon her from the Engliſh. The enemy finding ſuch entertainment provided for them before the boom, ſent off four *men of war* and the two *bomb-ketches*, who lying to the ſouthward of the mole, and firing over it, raked the Engliſh fore and aft; who on account of their former diſpoſition could not bring one gun to bear upon the enemy, neither from the four ſhips nor from the mole; under theſe circumſtances, the commanders judged it beſt to ſink the ſhips. In the evening the French ſtood out of the bay, and next day ſtood in again; and having poſted ſome *men of war* and their two bomb-ketches againſt the caſtle and mole, they ſent in a ſtoreſhip they had turned into a fireſhip, and burnt the upper works of three ſinking ſhips; for the *Italian merchant*'s forecaſtle being under water, ſaved the Shandois.

210. *Diſpoſition of the Engliſh fleet at Cadiz* 1695.

The 16th of October *Sir George Rooke* arrived in the bay of Cadiz with the fleet under his command, and on the 21ſt it was reſolved in a council of war, that as there were but 30 ſhips of the line, which was not a force ſufficient to oppoſe the enemy, who were expected to be above double that number, all that could be propoſed till the fleet ſhould be reinforced from England, was to protect the trade: But leſt the French ſhould appear at *Cadiz* before this reinforcement arrived, it was agreed that the ſhips ſhould be removed within *Puntal* caſtle, and formed in three lines; which was all that could be done, the ſhips being in general but half manned, and the Dutch ſhips very foul.

Theſe three lines were to be as follows: The firſt, to conſiſt of the largeſt Engliſh ſhips, to lie from *Puntal* thwart the channel, to the creek's mouth called *Truccadero*, next within the north caſtle: The ſecond, to be compoſed of the ſmalleſt Engliſh and Dutch ſhips, along the ſhoal on the ſouth ſide of the harbour: And the third, to be of the largeſt Dutch ſhips, to begin from the upper end of the ſecond line, and to trench away thwart the channel, to the mouth of the upper creek, which goes to *Port Real*; and the ſmall frigates, bomb-veſſels, and fireſhips, were to be poſted to the beſt advantage, as the wind and other circumſtances might permit. However, the fleet was not attacked, and about the middle of March *Sir George* put to ſea on his return to England, and arrived in the Channel the 22d of April.

211. *Fortifications in the harbour of St. John in Newfoundland* 1697.

Commodore *Norris* being ſent with a fleet to recover Hudſon's bay, put into the harbour of St. John in Newfoundland, upon hearing a large French fleet were upon the coaſt of North America; and not knowing the ſtrength of the enemy, he judged it prudent to ſecure his force, that it might be employed in the ſervice he was ſent on. He therefore put his ſquadron into a line of battle, which was compoſed of four fourth rates, two fifth, and two ſixth rates, with two fireſhips, two bomb-veſſels, and a hag boat: Two booms were laid acroſs the harbour, and Colonel Gibſon's regiment, that was carried by the ſquadron from England, were embarked, and ſeveral guns mounted on the batteries aſhore.

When the French ſquadron came in ſight, the foregoing diſpoſition was altered: All the *men of war* lay in a half moon to the harbour's mouth; and each ſhip's broadſide commanded the two booms: Colonel Gibſon's regiment was poſted at the two batteries, and about the harbour's mouth, and Captain Richards (who was the engineer for fortifying the harbour) was making ſuch works as he judged neceſſary on this occaſion; and that the ſquadron might be better able to do ſervice, all the men were taken from the merchant ſhips and put on board them.

The French fleet made no attempt on the harbour; but, on the contrary, were glad to find that the Engliſh had been miſinformed of their ſtrength, and ſo ſhaped their courſe for Europe.

212. *The battle of Vigo, in the year* 1702.

Monſieur *Chateau-Renault* arriving early in September at Vigo in Gallicia, with the Spaniſh galleons under his convoy, received information of the Engliſh and Dutch fleets being before Cadiz; of which timely intelligence he made all the advantage he could in preparing for their reception.

In the upper end of *Vigo bay* is a river running into the bay; up this river is *Redondella* harbour, which is ſurrounded with hills in ſuch a manner, as to be capable of being made very ſtrong, the harbour's mouth not being above a muſket ſhot over. On the north ſide the entrance was a battery of eight braſs, and twelve iron guns, and on the ſouth ſide a platform with twenty ſtately braſs guns, and twenty good iron guns, beſides a ſtone fort, with a trench about it, mounted with ten guns, and defended by 500 men. A little above the battery on the right, from two points in a narrow gut, was ſtretch'd a cable, to which was laſhed maſts, yards, caſks, &c. with their top-chains, and frap'd about with four inch rope very thick: The bight of the boom was rid by three anchors down the ſtream, that ſhould the Engliſh ſhips come ſtemlings againſt it, they might not bring home the anchors upon the ſhelf at the end of the boom; or if they cut it in one place, the whole might not be open: To flank the boom, there was moor'd the L'Eſperance, a ſhip of ſeventy guns, on the ſouth ſide, and the Le Bourbon, a ſhip of ſeventy-ſix guns, on the north ſide; alſo five men of war, of ſixty and ſeventy guns each, lay moor'd with their broadſides flanking the gut. The French admiral, to give him his due commendation, had taken all human precautions to ſecure his fleet.

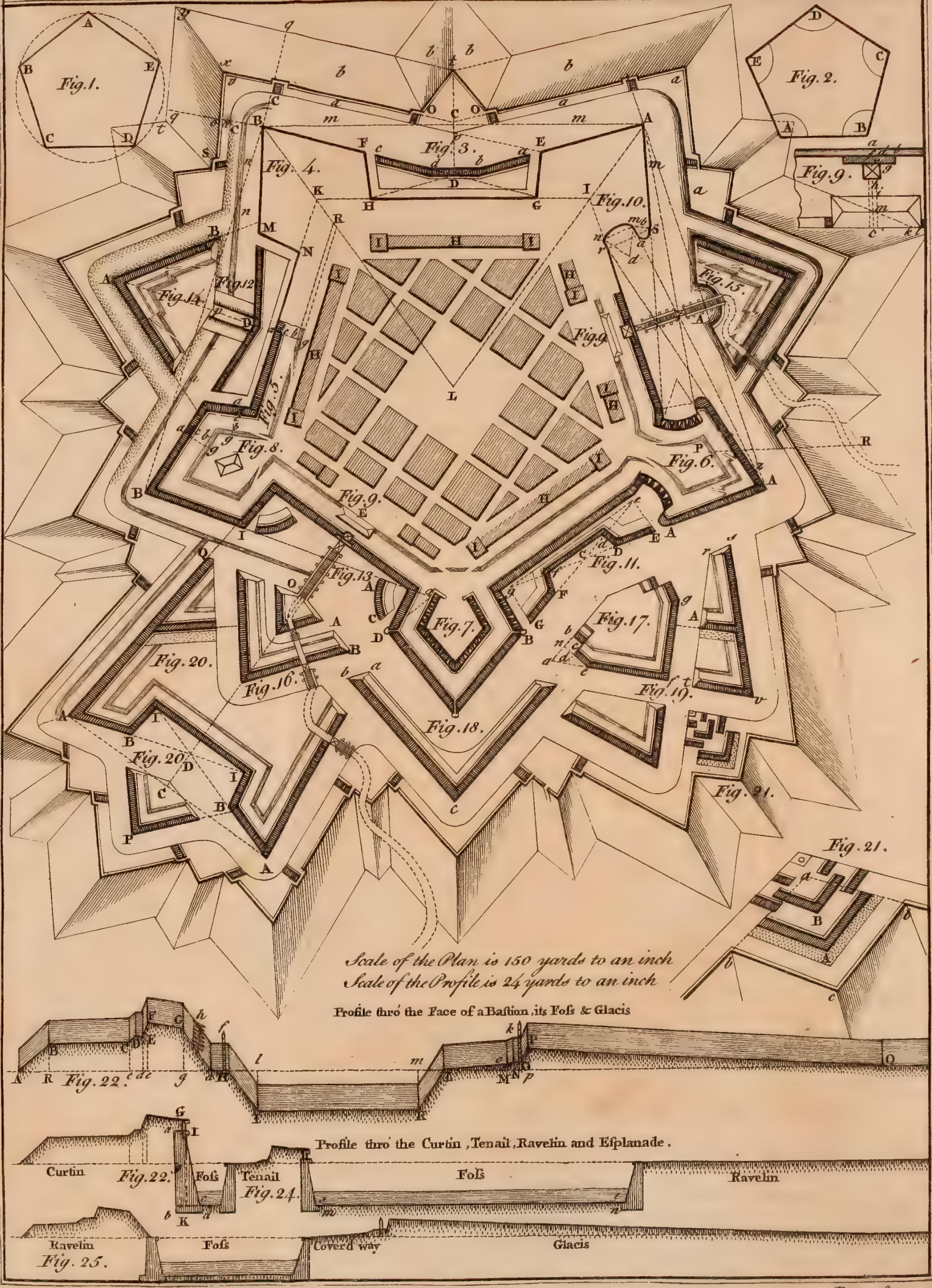
When the confederate fleet came before the place, Sir George Rooke called a council of war, and it was reſolved to attempt the forcing of the harbour the next morning. As ſoon as the land forces were got on ſhore, the 12th of October in the morning, the admiral gave the ſignal to weigh, the line was formed, and the ſquadron was briſkly bearing up to the boom; but when the van was got within ſhot of the batteries, it fell calm, ſo that they were neceſſitated to come to anchor: However, a freſh gale ſpringing up not long after, Vice-admiral *Hopſon*, in the *Torbay*, being next the enemy, immediately cut his cables, clapt on all his ſails, and bearing up directly againſt the boom, amidſt all the enemy's fire, broke thro' it at once, caſt anchor between the L'Eſperance and Bourbon, and with unparallel'd reſolution received ſeveral broadſides from them. The reſt of Vice-admiral *Hopſon*'s diviſion, and Vice-admiral *Vandergoe*'s with his detachment, having weighed at the ſame time, ſailed abreaſt towards the boom, to add the greater weight and force to the ſhock, but being becalmed they all ſtuck, and were obliged to hack and cut their way thro'; but a freſh gale blowing again, the Dutch Vice-admiral made ſuch good uſe of it, that having hit the paſſage which the valiant *Hopſon* had made, he went boldly in, and made himſelf maſter of the *Bourbon*. All this while Admiral *Hopſon* was in great danger, for being clapt on board by a French fireſhip, whereby his rigging was preſently ſet on fire, he expected every moment to be burnt; but it very fortunately fell out, that the French ſhip, which indeed was a merchantman laden with ſnuff, and fitted up in haſt for a fireſhip, being blown up, the ſnuff in ſome meaſure extinguiſhed the fire, and preſerved *Hopſon*'s ſhip from being conſumed, which however received very conſiderable damage in this action: At the ſame time Captain *Bokenham*, in the *Aſſociation* of ninety guns, laid his broadſide againſt a battery of ſeventeen guns on the left ſide the harbour, while Captain *Wyvell* in the *Barfleur*, a ſhip of like force, was ſent to batter the fort on the other ſide. Thus for a long while there was a conſiderable firing of great and ſmall ſhot on both ſides, till the French admiral ſeeing the platform and fort in the hands of the Engliſh, his fireſhip ſpent in vain, the *Bourbon* taken, the boom broke, and the confederate fleet pouring in upon him, he ſet fire to his own ſhip, and ordered the reſt of the captains under his command to follow his example, which was done in great confuſion; yet could he not be ſo punctually obeyed, but that ſeveral men of war and galleons were taken by the *Engliſh* and *Dutch*.—In this action it ſhould be obſerved, that the ſucceſs of the fleet was in a great meaſure owing to the land forces under the command of the Duke of *Ormond*, who not only drove away ſeveral bodies of troops deſtined for the defence of the ſhore, but alſo took the caſtle and platform on the ſouth ſide, which might otherwiſe have done great damage to the fleet.

There have been in the laſt war ſeveral gallant attempts made on fortified harbours, ſuch as thoſe of Admiral *Vernon* at *Porto-bello*, and *Carthagena*; of the Admirals *Anſon*, *Warren*, *Knowles*, and other brave officers; and alſo ſeveral booms have been ſet up in different harbours; but as theſe tranſactions are freſh in every one's mind, and the accounts of them common enough to be met with, they are here omitted: But it ſhould be obſerved, that all the booms which have been lately ſet up, were placed oblique to the ſtream; and is now become a general maxim among the marine officers.

FINIS.

FORTIFICATION

Pl. XIII



Scale of the Plan is 150 yards to an inch
Scale of the Profile is 24 yards to an inch

Profile thro' the Face of a Baſtion, its Foſs & Glacis

Profile thro' the Curtin, Tenail, Ravelin and Eſplanade.

20,000)

N PUBLIC

lume allowed at a time, and obtain
ept 14 days (or seven days in the ca
books published within one year) wi
wed; to be reclaimed by messeng
l collect 20 cents besides fine of 2 c
ida [illegible] holidays; not to be lent
nd not to be transferre

k mutilated or u
; and also any

of
tl